# Catalogue Data in Autumn Semester 2024

## Agricultural Sciences Bachelor

### 1. Semester

#### First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-2001-02L</td>
<td>Chemistry I</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>J. Cvengros, J. E. E. Buschmann, P. Funck, R. Verel</td>
</tr>
</tbody>
</table>

**Abstract**

General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course "Chemistry I", the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

**Objective**

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

**Content**

1. **Stoichiometry**
   - Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. **Atoms**
3. **Chemical bonding and its representation.**
4. **Basics of chemical thermodinamics**
   - System and surroundings. Description of state and change of state of chemical systems.
5. **First law of thermodinamics**
6. **Second law of thermodinamics**
   - Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. **Gibbs energy and chemical potential.**
8. **Combination of laws of thermodinamics.**
9. **Chemical equilibrium**
10. **Acids and bases**
11. **Dissolution and precipitation.**

**Lecture notes**

Online-Skript mit durchgerechneten Beispielen.

**Literature**


Weiterführende Literatur:


Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(englisch)

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<td>assessed</td>
<td>assessed</td>
<td>fostered</td>
<td>fostered</td>
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</table>

| 401-0251-00L | Mathematics I | O | 6 credits | 4V+2U | A. Cannas da Silva |

**Abstract**

This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

**Objective**

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both of these courses.
1. Single-Variable Calculus:  
   review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

2. Linear Algebra and Complex Numbers:  
   systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

3. Ordinary Differential Equations:  
   separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

Literature  
- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

Prerequisites / notice  
Prerequisites: familiarity with the basic notions from Calculus, in particular those of function and derivative.

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551-0001-00L  
**General Biology I**  
**O** 3 credits  **3V**  
U. Sauer, O. Y. Martin, A. Widmer  

**Abstract**  
Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny. First in a series of two lectures given over two semesters for students of agricultural and food sciences, as well as of environmental sciences.

**Objective**  
The understanding of some basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

**Content**  
The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

- Week 1-7 by Alex Widmer, Chapters 12-25
- Week 8-14 by Oliver Martin, Chapters 26-34

**Literature**  

**Prerequisites / notice**  
The lecture is the first in a series of two lectures given over two semesters for students with biology as a basic subject.

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701-0243-01L  
**Biology III: Essentials of Ecology**  
**O** 3 credits  **2V**  
J. Alexander  

**Abstract**  
This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.

**Objective**  
The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented. A further aim of the lecture is that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.

**Content**  
- Biodiversity: variation, threats and conservation
- Influence of environmental factors on organisms; adaptation to environmental conditions
- Population dynamics: causes, description, prediction and regulation
- Interactions between species (competition, coexistence, predation, parasitism, food webs)
- Ecological communities: structure, stability, succession
- Ecosystems: compartments, material and energy flows

**Literature**  

**Competencies**  
- Subject-specific Competencies  
  - Concepts and Theories
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Communication
  - Cooperation and Teamwork
  - Sensitivity to Diversity
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

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701-0027-00L  
**Environmental Systems I**  
**O** 2 credits  **2V**  
N. Dubois, A. Hall, R. Knutti  

**Abstract**  
The lecture provides a science-based exploration of environmental aspects from three research fields: earth, climate, and health sciences.
This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, households, firms, and market structures, and moves on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

**Objective**
The students are able to explain important properties of the three environmental systems, to discuss critical drivers, trends and conflicts of their use, and to compare potential solutions.

**Content**
The lecture discusses the role of the environmental systems based on selected environmental problems, among these the exploration of raw materials and fossil fuels, climate change and its impacts on man and environment, and the spread and control of infectious diseases in the human population and agricultural systems.

**Lecture notes**
Slides are provided by instructors and are accessible via moodle.

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**World Food System**

**Abstract**
Die Grundlagen des Welternährungssystem werden anhand von Fallbeispielen aus der Forschung entlang der Wertschöpfungskette vermittelt.

**Objective**
Mit Besuch dieser Lehrveranstaltung soll Verständnis geschaffen werden, was ein Welternährungssystem ist, wo aktuell die grossen Herausforderungen liegen, was Elemente und Einflussfaktoren auf die Ernährungssicherheit sind, welche Wechselwirkungen zwischen diesen Elementen und Einflussfaktoren bestehen, und welche potentiellen Lösungsstrategien sich für spezifische Herausforderungen ableiten lassen.

**Content**

**Lecture notes**
Skripte und zusätzliches Lernmaterial werden auf Moodle verfügbar gemacht.

**Literature**
Information zu Büchern und anderer Literatur wird während der Lehrveranstaltung bekanntgegeben.

**Prerequisites / notice**

Das Fach ist Teil der Basisprüfung nach dem ersten Studienjahr.


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**Economics**

**Abstract**
This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, households, firms, and market structures, and moves on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

**Objective**
After successful completion of the course you will be able to:

- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

**Content**
Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

**Lecture notes**
No script available

**Literature**
### Additional First Year Courses

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>751-0801-00L</td>
<td>Fundamentals of Microscopy and Plant Biology</td>
<td>O</td>
<td>1</td>
<td>1V+2G</td>
<td>E. B. Truenit</td>
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<tr>
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<td>Abstract</td>
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<td>Capability of preparing biological specimen, microscopy and documentation. Understanding the correlation between plant structure and function at the level of organs, tissues and cells.</td>
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<td>Awareness of the link between plant anatomy, systematics, physiology, ecology, and development.</td>
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<td>Lecture notes</td>
<td>Online in Moodle Course</td>
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<td></td>
<td>Literature</td>
<td>For further reading (not obligatory):</td>
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<td>Prerequisites / notice</td>
<td>Groups of a maximum of 20 students.</td>
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<td>Competencies</td>
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<td>Method-specific Competencies Analytical Competencies</td>
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<td>Social Competencies Communication</td>
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<td>Personal Competencies Critical Thinking</td>
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<tr>
<td>529-0030-00L</td>
<td>Laboratory Course: Elementary Chemical Techniques</td>
<td>O</td>
<td>3</td>
<td>4P</td>
<td>A. de Mello, F. Jenny, N. Kobert, M. H. Schroth</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>This practical course provides an introduction to elementary laboratory techniques. The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g. investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.</td>
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<td>This course is intended to provide an overview of experimental chemical methods. The handling of chemicals and proper laboratory techniques represent the main learning targets. Furthermore, the description and recording of laboratory processes is an essential part of this course.</td>
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<td>Content</td>
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<td>The classification and analysis of natural and artificial compounds is a key subject of this course. It provides an introduction to elementary laboratory techniques, and the experiments cover a wide range of analytic and synthetic tasks: Selected samples (e.g. soil and water) will be analysed with various methods, such as titrations, spectroscopy or ion chromatography. The chemistry of aqueous solutions (acid-base equilibria and solvatation or precipitation processes) is studied. The synthesis of simple inorganic complexes or organic molecules is practised. Furthermore, the preparation and handling of environmentally relevant gaseous species like carbon dioxide or nitrogen oxides is a central subject of the Praktikum.</td>
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<td></td>
<td>Lecture notes</td>
<td>The instructions to the experiments will be published on Moodle.</td>
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<td>Literature</td>
<td>A thorough study of all script materials is requested before the course starts.</td>
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<td>Competencies</td>
<td>Subject-specific Competencies Concepts and Theories</td>
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<td>Method-specific Competencies Techniques and Technologies</td>
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<td>Social Competencies Cooperation and Teamwork</td>
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<tr>
<td>252-0839-00L</td>
<td>Informatics</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>M. Dahinden, L. E. Fässler</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists, tables and relational databases, introduction to programming.</td>
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<td>Objective</td>
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<td>The students learn to...</td>
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<td>- choose and apply appropriate tools from computer science,</td>
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<td>- process and analyze real-world data from their subject of study,</td>
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<td>- handle the complexity of real-world data,</td>
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<td>- query databases and understand and evaluate the corresponding database model,</td>
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<td>- encode a problem into a program, test the program, and correct errors,</td>
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<td>- implement models from the natural sciences as a simulation.</td>
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<td>Content</td>
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<td></td>
<td>1. Modeling and simulations</td>
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<td>2. Data management with lists and tables</td>
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<td>3. Data management with a relational database</td>
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<td>4. Introduction to programming with Python 1 (variables &amp; data types)</td>
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<td>5. Introduction to programming with Python 2 (control structures &amp; logic)</td>
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<td>6. Introduction to programming with Python 3 (sequential data structures)</td>
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<td></td>
<td>Lecture notes</td>
<td>All materials for the lecture are available at <a href="http://www.evim.ethz.ch">www.evim.ethz.ch</a></td>
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<td></td>
<td>Prerequisites / notice</td>
<td>This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.</td>
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Basic Courses (Second Year)

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>402-0063-00L</td>
<td>Physics II</td>
<td>O</td>
<td>5</td>
<td>3V+1U</td>
<td>A. Vaterlaus</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Introduction to the way physicists think and work with the help of concept questions, demonstration experiments and problem solving. Wherever possible, applications from thermodynamics, electricity and magnetism are taught from the areas of the degree programmes.</td>
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<td><strong>Objective</strong></td>
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<td>Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>Thermodynamics with first and second law, phase transformations, transport phenomena. Introduction to electricity and magnetism, as well as waves and modern physics.</td>
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<td><strong>Lecture notes</strong></td>
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<td>A script will be distributed</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td>Friedhelm Kuypers</td>
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<td>Physik für Ingenieure und Naturwissenschaftler</td>
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<td>Band 2 Elektizität, Optik, Wellen</td>
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<td>Wiley-VCH, 2012</td>
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<td>ISBN 3527411445, 9783527411443</td>
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<td>(4. Auflage 2022)</td>
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<tr>
<td>701-0071-00L</td>
<td>Mathematics III: Systems Analysis</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>C. Brunner, R. Knutti, H. Wernli</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.</td>
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<td>Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.</td>
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<td><strong>Content</strong></td>
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<td><strong>Lecture notes</strong></td>
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<td>Overhead slides will be made available through the course website.</td>
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<tr>
<td>401-0624-00L</td>
<td>Mathematics IV: Statistics</td>
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<td>4</td>
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<td>N. Meinshausen</td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Capacity to learn from data; good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
<td></td>
<td></td>
<td></td>
<td>Einführung in die Wahrscheinlichkeitsrechnung (Grundregeln, Zufallsvariablen, diskrete und stetige Verteilungen, Ausblick auf Grenzwertsätze), Beschreibende Statistik (einschliesslich grafische Methoden). Methoden der Analytischen Statistik: Schätzungen, Tests (einschliesslich Binomialtest, t-Test, Vorzeichenstest, F-Test, Wilcoxon-Test), Vertrauensintervalle, Vorhersagesintervalle, Korrelation, einfache und multiple lineare Regression. Einführung in die statistische Programmiersprache R.</td>
</tr>
<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
<td></td>
<td></td>
<td></td>
<td>Ausführliches Skript zur Vorlesung ist erhältlich.</td>
</tr>
<tr>
<td></td>
<td><strong>Literature</strong></td>
<td></td>
<td></td>
<td></td>
<td>Stahel, W.: Statistische Datenanalyse. Vieweg, 5. Auflage 2008 (als ergänzende Lektüre)</td>
</tr>
<tr>
<td></td>
<td><strong>Prerequisites / notice</strong></td>
<td></td>
<td></td>
<td></td>
<td>Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung. Voraussetzungen: Mathematik I, II</td>
</tr>
<tr>
<td>752-4001-00L</td>
<td>Microbiology</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>M. Schuppler, M. La Fortezza, M. Pilhofer, S. Robinson</td>
</tr>
<tr>
<td></td>
<td>Some parts of the lecture will be taught in English.</td>
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</tr>
</tbody>
</table>
Abstract
Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

Objective
Teaching of basic knowledge in microbiology.

Content

Lecture notes
Wird von den jeweiligen Dozenten ausgegeben.

Literature
Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Analysis Competencies
Vermittlung von betriebswirtschaftlichen Grundlagenwissen und Analyse- und Planungsinstrumenten mit Anwendung auf Unternehmen der Agrar- und Ernährungswirtschaft.

Content
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.

Lecture notes
Polybook

Literature

Prerequisites / notice
Prerequisites: Basic knowledge in chemistry, biology and geology.

701-1501-00L Introduction to Agricultural Management O 2 credits 2V R. Kretzschmar

Abstract
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.

Objective
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

Content
The course "Pedosphäre" teaches and examines the competencies process understanding and systems understanding.

Literature
701-1501-00L Introduction to Agricultural Management O 2 credits 2V R. Kretzschmar

Abstract
Vermittlung von betriebswirtschaftlichen Grundlagenwissen und Analyse- und Planungsinstrumenten mit Anwendung auf Unternehmen der Agrar- und Ernährungswirtschaft.

Objective
Teilnehmer des Kurses sollen am Ende der Vorlesung i) grundlegende Unternehmensentscheide strukturieren und analysieren können, ii) verschiedene Analyse- und Planungsinstrumente auf Fragestellungen der Produktionsplanung, Investition und Finanzierung an Beispielen anwenden zu können, iii) verschiedene Werkzeuge zur unternehmerischen Entscheidungsunterstützung anwenden können und iv) die Spezifika von Unternehmen in der Agrar- und Ernährungswirtschaft kennen.

Content
Die Vorlesung geht auf folgende Inhalte, mit spezifischen Anwendungen im Agrar- und Ernährungssektors ein:

Comprehensives
Concepts and Theories
Techniques and Technologies

Analysis Competencies
Analytical Competencies
Problem-solving

Communication
Sensitivity to Diversity

Adaptability and Flexibility
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

751-1311-00L Introduction to Nutritional Science O 2 credits 2V R. Finger

Abstract
This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates.

Objective
To introduce the students to the both the macro- and the micronutrients.

Content
The course is devided into two parts: Macronutrients and macronutrients. The micronutrient part includes fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. The macronutrient part introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism. The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeoeosis are emphasized.

Lecture notes
There is no script. Powerpoint presentations will be made available.
## Literature

Elmadfa I & Leitzmann C: Ernährung des Menschen
UTB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004

Garrow JS and James WPT: Human Nutrition and Dietetics
Churchill Livingstone, Edinburgh, 11th rev. ed. 2005

## Competencies

### Subject-specific Competencies

<table>
<thead>
<tr>
<th>Concepts and Theories</th>
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## Agricultural Sciences Basic Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-8003-00L</td>
<td>Genetics in Agricultural Sciences</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>H. Pausch, B. Studer</td>
</tr>
</tbody>
</table>

**Abstract**

Important concepts from population, quantitative and molecular genetics are introduced and applied to plant and animal populations.

**Objective**

After the course, the students will be able to:

- work with genetic polymorphisms and explain mechanisms underlying allele frequency changes in natural and experimental populations;
- determine factors affecting the selection intensity
- explain the difference between genotypic and phenotypic values
- quantify the expected genetic gain per time unit
- explain important molecular methods to determine genetic polymorphisms;
- map traits in plant and animal populations using molecular marker information;
- integrate different concepts from population, molecular and quantitative genetics and explain their importance for applications in genetics in agricultural sciences.

**Content**

- Molecular genetics (15%)
  - DNA sequence variation
  - Marker & genotyping technologies (SSRs, AFLPs, SNPs, KASP, GBS, RADseq, AmpSeq, Chip Technologies)
- Population genetics (30%)
  - Allele- and genotype frequencies in populations
  - Hardy-Weinberg equilibrium
  - Genetic drift, differentiation of populations
  - Fitness, selection
  - Inbreeding, relationship, effective population size
- Quantitative genetics (40%)
  - Recombination, crossing over, linkage analysis, genetic mapping
  - QTL mapping
  - Forms of selection and selection differential
  - Heritability
  - Quantification of expected genetic gain
  - Genotypic value, allele substitution effect, breeding value
- Integrative genetics (15%)
  - Genome-wide association mapping
  - Estimation of genomic breeding values

**Lecture notes**

Slides and exercises will be provided in advance of each class via Moodle.

**Literature**

Further reading:

- Falconer & Mackay: Introduction to Quantitative Genetics
- Lübberstedt & Varshney: Diagnostics in Plant Breeding

**Prerequisites / notice**

German

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Methodsistic Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
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</table>

## Agricultural Sciences Disciplines

### Agricultural Economics

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>351-1109-00L</td>
<td>Introduction to Microeconomics</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>M. Wörter, M. Beck</td>
</tr>
</tbody>
</table>

**Abstract**

This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

**Objective**

Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 7 of 2667
751-0903-00L  Microeconomics of the Agriculture and Food Sector  W+ 3 credits  2V  L. Zachmann

Abstract
In dieser Vorlesung werden ökonomische Charakteristika des Agrar- und Lebensmittelsektors herausgearbeitet und anderen Sektoren gegenübergestellt. Fokus ist dabei Lebensmittelindustrie in der Schweiz und in der EU. Es werden mikroökonomische Zusammenhänge, insbesondere zur Preis- und Mengenbildung in verschiedenen Wettbewerbsmodellen, am Fallbeispiel des Agrar- und Ernährungssektors vermittelt.

Objective

Content
- Der Agrar- und Lebensmittelsektor in der EU und der Schweiz
- Preiselastizitäten von Angebot und Nachfrage im Ernährungssektor
- Gewinnmaximierung
- Grundlagen der Spieltheorie
- Monopol / Monopolistischer Wettbewerb
- Oligopol (Stackelberg, Cournot, Bertrand)
- Monopson
- Produktdifferenzierung
- Preisdiskriminierung
- Kartelle
- Pindyck und Rubinfeld, Mikroökonomie, 7. Aufl., Pearson Studium.

Literature

Prerequisites / notice
Empfohlene Vorkenntnisse:
- Grundkenntnisse der Ökonomie/Agrarökonomie
- Vorlesung Einführung in die Mikroökonomie

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Method-specific Competencies
- Negotiation

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Self-awareness and Self-reflection

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

751-0401-00L  Optimization of Agricultural Production Systems  W+ 3 credits  2G  R. Huber

Abstract
Introduction in to optimization of agricultural production systems with linear and non-linear programming models.

Objective
Students will be able to a) solve linear and non-linear optimization problems in the context of agricultural production; b) properly interpret the results; and c) critically discuss the economic implications.

Content
The course is an application of Operations Research (OR). First, the theory and application of linear programming (LP) is presented. Students will learn the underlying principles (Optimization, Duality, Simpex) and solve exercises in the context of agricultural production. In the second part of the course, the foundation of non-linear programming (NLP) is introduced (Lagrange, Kuhn-Tucker) and illustrated with various examples.

Lecture notes
Handed out during lecture

Literature

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Method-specific Competencies
- Negotiation

751-0301-00L  Resource and Environmental Economics  W+ 3 credits  2G  A. Miftakhova, A. Minabutdinov

Abstract
Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economics theory and policy at international level, e.g. to the problem of climate change.

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

**Literature**


**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies

**Subject-specific Competencies**

**Method-specific Competencies**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-2120-00L</td>
<td>Consumer Behaviour I</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Siegrist, A. Bearth, A. Berthold</td>
</tr>
<tr>
<td>363-0711-00L</td>
<td>Accounting for Managers</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>H. Chen, to be announced</td>
</tr>
</tbody>
</table>

**Course Details**

**Objective**

- After attending the class, you should be able to:
  - understand the accounting system, the reporting process, and be able to prepare financial statements
  - feel comfortable reading and using the information presented in companies’ annual reports
  - understand cost concepts and conduct cost analyses
  - become familiar with several classic decisions using managerial accounting information
  - comment on the current events related to these topics

**Content**

- Accounting plays a critical role in the effective functioning of the financial market as well as the long-term success of a company. This course intends to provide an introduction to accounting for those who wish to pursue a career in business, and need the skills and knowledge to understand, analyze, and interpret accounting information to make informed decisions. The course is divided into two parts. In the first part, we focus on financial reporting and start with the basic accounting concepts and the accounting cycle, to learn how the financial system is set up in a company and how financial statements are prepared. We then delve deeper into each major account, and discuss how revenues and expenses are recognized, and how assets, liabilities, and equities are reported. In the second part, we focus on managerial accounting for internal managerial/operational decisions including fundamental topics such as cost behavior, cost estimation, CVP analyses, and relevant costing. We then cover budgeting and standard costing, which are important parts of accounting system in companies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-3700-00L</td>
<td>Plant Ecophysiology</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>N. Buchmann, A. Walter</td>
</tr>
</tbody>
</table>

**Objective**

- The general theme of this course is the effect of environmental factors (such as light, temperature, relative humidity, CO2 concentrations, etc.) on plant physiology: water uptake and transport, transpiration, CO2 gas exchange of plants (photosynthesis, respiration), growth and C allocation, yield and production, stress physiology. Working with measurement data and Jupyter Notebooks is included.

**Abstract**

- The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology that is necessary to analyze yield potentials in agriculture. The students will learn about classical and latest studies in plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.
## Plant Nutrition I

<table>
<thead>
<tr>
<th>751-3401-00L</th>
<th>Plant Nutrition I</th>
<th>O</th>
<th>2 credits</th>
<th>2V</th>
<th>E. Frossard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The aim of these lecture is to present the processes controlling the uptake and transport of nutrients by the plant, the assimilation of nutrients in the plant, the effect of nutrients on crop yield and quality, the role of the soil as a source of nutrients for crops, and the basic principles of fertilization of different crop types using mineral and organic fertilizers.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>At the end of the lecture, students know how mineral nutrients are taken up through roots and circulate in the plants and what their roles in plants are. They understand the importance of nutrients for yield formation and for crop product quality. They are able to propose fertilization plans adapted for field crops growing under Swiss conditions.</td>
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<tr>
<td><strong>Content</strong></td>
<td>A general introduction explains the needs of appropriately managing nutrients in plant production. Afterwards, we will study the physiology of plant nutrition (nutrient uptake by roots; nutrient transports in the plant; physiological roles of nutrients in the plant). Then the role of nutrients for yield formation and their effects on crop quality is dealt with. Finally, the bases of crop fertilization are taught (availability of nutrient in soil; N, P and K fertilization; different types of fertilizers).</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>The slides will be distributed</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Marschner's Mineral Nutrition of Plants Fourth Edition 2023, edited by Zed Rengel, Ismail Cakmak and Philip J. White; (available online on the ETH library).</td>
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</table>

### Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
<td></td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td></td>
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<tr>
<td>Problem-solving</td>
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</table>

### Prerequisites

- **Agriculture science students of the BSc program, 5. Semester**
- **Students of other semesters or study programs, who will be selected with a view to forming four interdisciplinary and diverse teams.**

- **Convincing motivational letter**
- **Agricultural science students of the BSc program, 5. Semester**
- **Students of other semesters or study programs, who will be selected with a view to forming four interdisciplinary and diverse teams.**

- **Send a motivational letter of max. 100 words and send it via email to Achim.Walter@usi.ethz.ch until (25.9.). Participants will be selected according to the following criteria:**
  1. Convincing motivational letter
  2. Agricultural science students of the BSc program, 5. Semester
  2. Students of other semesters or study programs, who will be selected with a view to forming four interdisciplinary and diverse teams.

### Literature

- Richter W. & Sinaj S., 2017. Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD 2017). Agrarforschung Schweiz 8 (6), Spezialpublikation,
- Schubert S 2011 Pflanzenenernährung Grundwissen Bachelor Ulmer UTB
- Schubert S 2011 Düngung Grundwissen Bachelor Ulmer UTB
- Schubert S 2011 Pflanzenenernährung Grundwissen Bachelor Ulmer UTB

## Startup for Smart Sustainable Farming

<table>
<thead>
<tr>
<th>751-4108-00L</th>
<th>Startup for Smart Sustainable Farming</th>
<th>W+</th>
<th>3 credits</th>
<th>2G</th>
<th>A. Walter, M. Binggeli</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Agriculture needs to become more sustainable via innovative approaches. This course allows students to explore in group work, how this could be realized. There are short impulse talks on 'Smart Farming' given by experts on technology, sustainability and entrepreneurship. Most importantly, students elaborate the first steps to create a startup company in this field.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>During the course, the students generate their own ideas. They explore e.g., which technologies provide possibilities for a more sustainable agriculture. They simulate the creation of a startup company in a team.</td>
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<tr>
<td><strong>Prerequisites</strong></td>
<td>Maximum number of students: 16 (four teams will be formed)</td>
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<tr>
<td><strong>notice</strong></td>
<td>All students interested should come to the first lecture (25th September). There, details of this year's format will be explained. In case students are still interested to visit the class, they have to write a motivational letter of max. 100 words and send it via email to <a href="mailto:Achim.Walter@usi.ethz.ch">Achim.Walter@usi.ethz.ch</a> until (27th September). Participants will be selected according to the following criteria: 1.) Convincing motivational letter 2.) A conviction that students of the BSc program, 5. Semester 2. Students of other semesters or study programs, who will be selected with a view to forming four interdisciplinary and diverse teams. The definitive acceptance to the course will be communicated to students by (29th September). The definitive inscription will subsequently been done by the study secretariat.</td>
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</tbody>
</table>
Fostered Concepts and Theories

Fostered Techniques and Technologies

Fostered Decision-making

Fostered Media and Digital Technologies

Fostered Problem-solving

Assessed Project Management

Assessed Communication

Assessed Cooperation and Teamwork

Assessed Leadership and Responsibility

Assessed Self-presentation and Social Influence

Assessed Sensitivity to Diversity

Assessed Negotiation

Assessed Adaptability and Flexibility

Assessed Creative Thinking

Assessed Critical Thinking

Assessed Integrity and Work Ethics

Assessed Self-awareness and Self-reflection

Assessed Self-direction and Self-management

751-4504-00L  Plant Pathology I  W+  2 credits  2G  B. McDonald

Abstract

Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems.

Objective

Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.

Content

Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytotoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.


Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.


Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Lecture notes  Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

751-5003-00L  Sustainable Agroecosystems II  W+  2 credits  2V  K. Benabderrazik, J. Six

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 11 of 2667
Abstract
This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

Objective
(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content
The course will address a wide range of agricultural and food system challenges (e.g. food security, climate crisis, soil degradation, etc.) in both temperate and tropical contexts. In class we will address topics like building food system resilience through innovative measures, improving soil fertility management or understanding the effects of agroforestry systems.

Case studies from the on-going research in the Sustainable Agroecosystems Group (sae.ethz.ch) will be presented, covering different scales (e.g. food value-chains, farm dynamics and soil management).

The class is complemented by practical group work conducted with the CSA Meh Als Gmuens in Zürich on Measuring and monitoring Agroecological performance.

Students will gain an overview on institutions and actors’ roles in the field of sustainable agricultural development. Throughout the group work, students will learn to engage directly with various stakeholders, monitor agroecological transition and communicate their research to a wider audience. Ultimately, this class should provide an overview on methods, tools, innovations and platforms that support a sustainable food transformation.

Literature


Prerequisites / notice
Prior participation in the lecture Nachhaltige Agrarkosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed

Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork assessed
Self-presentation and Social Influence fostered

Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed

Critical Thinking assessed
Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

751-4201-00L Horticulture W+ 2 credits 2V C. Carlen, A. Bühlmann, A. Náf, T. Schönberg, T. Verdenal

Abstract
The importance and specificities of the different horticultural crops are shown in this course in the autumn semester. It deals with fruit growing (8 h), berry production (4 h), vegetables (6 h) and viticulture (6 h).

Objective
You are able to describe the production systems of the horticultural crops: fruits, berries, vegetables and viticulture (yield formation and physiology, cultivation methods, main varieties, quality factors).

You are able to assess the importance of new conditions (climate, politics, trade) for the production of horticultural crops and identify options for action for production.

Content
The importance and specificities of the different horticultural crops are shown in this course in the autumn semester. It deals with fruit growing (8 h), berry production (4 h), vegetable growing (6 h) and viticulture (6 h).

Under the responsibility of Agroscope representatives, basic knowledge of production systems (yield formation and physiology, cultivation methods, main varieties, quality) of these horticultural crops, which are important in Switzerland, is imparted.

Case studies from the ongoing research in the Sustainable Agroecosystems Group (sae.ethz.ch) will be presented, covering different scales (e.g. food value-chains, farm dynamics and soil management).

Lecture notes
Delivered during the lectures by the different teachers, Moodle upload.

Literature
Not needed, maybe specific literature is specified by the different teachers.

Language and script: German or French, maybe selected parts in English.

Animal Sciences

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<th>Number</th>
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<td>751-6101-00L</td>
<td>Anatomy and Physiology of Humans and Animals I</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>S. E. Ulbrich, A.-K. Hankele, F. Trepp</td>
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</tbody>
</table>

Abstract
Imparts a basic understanding of physiology an anatomy in man and domestic animals, focusing on the interrelations between morphology and function of the organism, in particular of domestic animals. This is fostered by discussing all subjects from a functional point of view. The lecture consists of two consecutive parts.

Objective
The overall goal of this course is to enable students to understand basic functions of the vertebrate organism and to comprehend pathophysiological correlations.

Lecture notes
Handouts are provided by each lecturer separately.

Literature
The lecturers will recommend additional literature at the beginning of the course.
Prerequisites / notice

This lecture is part of the BSc programme in Agricultural Sciences (3rd semester)

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

751-7501-00L

Introduction to Housing and Behaviour of Farm Animals

Abstract
The overall goal of this course is to provide general knowledge about the behaviour, housing and welfare of domestic animals.

Objective
- Understand the basis of animal behaviour of farm animals
- Acquire knowledge of housing systems and management of domestic animals

Content
1- Introduction to housing
2- Introduction to animal behaviour
3- Housing and behaviour of pigs
4- Housing and behaviour of cattle
5- Housing and behaviour of small ruminants
6- Housing and behaviour of chickens

751-7101-00L

Applied Animal Nutrition

Abstract
The basics of planning of feeding and formulation of diets incl. the implications on nutrient cycles and balances are taught. In the part dealing with ruminants, forage-based diets and the application of feed formulation programs are central and exercised on-farm. With pigs and poultry, the basics of energy and nutrient requirements are deepened through practical examples.

Objective
- Students are able, based on the knowledge they obtain in this course, to deal with problems in the nutrition of ruminants, pigs and poultry on farm.

Content
- Programmtitel Wiederkäufer: Einführung in die Winterfütterungsplanung für Milchkühe, Betriebsbesuch (Erfassung aller notwendigen Daten inkl. Futterprobenentnahme für eine konkrete Planung auf einem Praxisbetrieb), Besonderheiten der Milchviehfütterung (Laktationsverlauf, Jahreszeit, etc.); Einführung in den LBL-Fütterungsplan, Möglichkeiten der Futterbeurteilung und -bewertung mit praktischer Beurteilung der gesammelten Proben, Berechnungen und Besprechung Fütterungsplan, Aufstellung der Mineralstoffbilanz, Vorführung von PC-Software zur Fütterungsplanung Vorstellen und diskutieren des Fütterungsplanes auf dem Praxisbetrieb durch die Gruppe.
- Programmtitel Nicht-Wiederkäufer: Der Energie- und spezifische Nährstoffbedarf beim Schwein und Geflügel; Besonderheiten der Nährstoffbedarfe von Schwein und Geflügel; Besonderheiten der Fütterung in den verschiedenen Produktionsphasen; Fütterungsempfehlungen und -hinweise. Rationengestaltung und -optimierung für Mischfuttermittel anhand verschiedener Beispiele; Einsatzgrenzen von Futtermittel; technologische Futterbearbeitung.

751-7103-00L

Animal Feed and Feeding of Ruminants

Abstract
The knowledge of the nutrition of ruminants and of the feeds used is deepened. Particular emphasis is put on the variety of home-grown feeds, their production and conservation and their application in the nutrition of dairy cows, cattle and small ruminants. Finally, information on specific problems of animal nutrition is communicated.
Objective
Purchase of basic skills in agricultural livestock nutrition.

Content

Lecture notes
Script is available in German language and will be provided by each lecturer when starting his part the lecture.

Literature
Eine Literaturliste ist im Skript enthalten.

Prerequisites / notice
Fach mit benoteter Prüfung am Ende der Lehrveranstaltung.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Project Management fostered
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Personal Competencies
Creative Thinking fostered
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

751-6121-00L Regulatory Physiology W+ 2 credits 2V S. E. Ulbrich, A. -K. Hankele, M. Saenz de Juano Ribes

Abstract
Zusammen mit nervaler Kontrolle, spielen Hormone und Zytokine als Signalmediatoren eine besondere Rolle bei der Regulation der Homöostase von Körperfunktionen (Flüssigkeits-, Temperatur-, Energie-Homöostase). Insbesondere im Zusammenhang mit pathologischen Konstellationen (Fieber, Stress, metabolische Imbalance, Schmerz) wird diese komplexe Funktion verständlich.

Objective

Content
- Thermoregulation (Fieber)
- Flüssigkeitshomöostase (Durchfall)
- Calciumregulation (Milchfieber)
- Energiehomöostase (Ketose)
- Schmerz (zootechnische Eingriffe)
- Stress (allostatische Last, Epigenetik)

Lecture notes
Unterlagen werden individuell von den Dozierenden abgegeben.

Literature
Spezifische Literatur wird individuell von den Dozierenden angegeben.

Prerequisites / notice
Diese Vorlesung ist Teil der BSc Agrarwissenschaften (5. Semester)

Methods

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-0441-00L</td>
<td>Scientific Analysis and Presentation of Data</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>H. Pausch, N. K. Kadri, A. Leonard</td>
</tr>
</tbody>
</table>

Abstract
Students will get an introduction to the scientific work with data covering all steps from data import from Excel via statistical analyses to producing correct scientific graphical output. Exercises with the software R/RStudio will provide hands-on opportunities to get acquainted with data analysis and presentation in adequate graphs.

Objective
This lecture with exercises gives an introduction to the scientific work with data, starting with data acquisition and ending with statistical analyses as they are often required for a bachelor thesis (descriptive statistics, linear regression, simple analyses of variance etc.). Using open-source R/RStudio software will be the primary focus via a hands-on approach. An important aspect will be to learn which graphical representation of data are best suited for the task (how can data be presented clearly and still scientifically correct?)
Content
Tentative Programme:
- Introduction
- Introduction to 'R'
- Data import and graphical presentation
- Correct and problematic graphical data displays
- Statistical distribution and confidence intervals
- Statistical tests - Repetition and hands-on applications
- Correlation analysis
- Linear regressions
- Analysis of Variance

Lecture notes
German and English

Prerequisites / notice
Theoretical background in ensemble statistics from the mandatory course in the 4th semester; students should have cleared the examination of that fundamental course to be able to follow

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Personal Competencies
Creative Thinking
Critical Thinking
Integrity and Work Ethics

751-1010-00L
Introduction to Scientific Methods Part II: Scientific Writing
O 3 credits 4G

Abstract
Die Studierenden kennen die Grundlagen und die Konventionen des wissenschaftlichen Schreibens in den Naturwissenschaften, können wissenschaftliche Literatur suchen und verwalten sowie wissenschaftliche Publikationen analysieren. Sie setzen das Gelernte beim Schreiben eines eigenen Textes um.

Objective
Die Studierenden kennen die Grundlagen und die Konventionen des wissenschaftlichen Schreibens in den Naturwissenschaften. Sie setzen das Gelernte beim Schreiben eines kritischen Literaturberichtes zu einem agrarwissenschaftlichen Thema ihrer Wahl um. Die Lehrveranstaltung bereitet die Studierenden auf weitere schriftliche Arbeiten im Studium der Agrarwissenschaften vor, beispielsweise auf die Bachelor-Arbeit.

751-0206-00L
Applied Laboratory Techniques in Agricultural Sciences
The course is compulsory for students in 5th semester BSc Agricultural Sciences.
O 3 credits 3P

Abstract
Die Lehrveranstaltung ist zweiteilig aus einem Laborpraktikum und einem angewandten Methodentraining aufgebaut. Im Laborpraktikum werden an 6 Kurstagen die wichtigsten Techniken der Molekularbiologie gelehrt. Das folgende Methodentraining findet an 5 Kurstagen im Block in einer der beteiligten Forschungsgruppen statt, um die wichtigsten Methoden aus dem jeweiligen Fachgebiet praxisnah anzuwenden.

Objective
- Aneignung von guter Laborpraxis (Sicherheit, Effizienz, Qualität und Dokumentation)
- Erlernen der wichtigsten Labor- und Feldmethoden in den Agrarwissenschaften sowie deren korrekte und sichere Anwendung
- Vertieftes Verständnis von molekularen, physiologischen und biochemischen Prozessen in aktuellen agrarwissenschaftlichen Themenbereichen
- Aneignung von Kompetenzen für zukünftige Bachelor-, Master-, und Doktorarbeiten
- Kritische Beurteilung der angewandten Methoden für verantwortungsvolle Forschung
The electives listed are recommended. However, electives can be chosen from the complete course offer of the ETH Zurich and University of Zurich.

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<tr>
<td>751-0903-00L</td>
<td>Microeconomics of the Agriculture and Food Sector</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>L. Zachmann</td>
</tr>
<tr>
<td>Abstract</td>
<td>In dieser Vorlesung werden ökonomische Charakteristika des Agrar- und Lebensmittelsektors herausgearbeitet und anderen Sektoren gegenübergestellt. Fokus ist dabei Lebensmittelindustrie in der Schweiz und in der EU. Es werden mikroökonomische Zusammenhänge, insbesondere zur Preis- und Mengenbildung in verschiedenen Wettbewerbssituationen, am Fallbeispiel des Agrar- und Ernährungssektors vermittelt.</td>
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<tr>
<td>Content</td>
<td>- Der Agrar- und Lebensmittelsektor in der EU und der Schweiz - Preiselastizitäten von Angebot und Nachfrage im Ernährungssektor - Gewinnmaximierung - Grundlagen der Spieltheorie - Monopol / Monopolistischer Wettbewerb - Oligopol (Stackelberg, Cournot, Bertrand) - Monopson - Produktdifferenzierung - Preisdiskriminierung - Kartelle</td>
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<td>Prerequisites / notice</td>
<td>Empfohlene Vorkenntnisse: - Grundkenntnisse der Ökonomie/Agrarökonomie - Vorlesung Einführung in die Mikroökonomie</td>
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<td>Method-specific Competencies: Analytical Competencies</td>
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<td>Social Competencies: Cooperation and Teamwork</td>
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<td>Personal Competencies: Critical Thinking</td>
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<tr>
<td>751-0401-00L</td>
<td>Optimization of Agricultural Production Systems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. Huber</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction in to optimization of agricultural production systems with linear and non-linear programming models. Students will be able to a) solve linear and non-linear optimization problems in the context of agricultural production; b) properly interpret the results; and c) critically discuss the economic implications.</td>
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<tr>
<td>Objective</td>
<td>The course is an application of Operations Research (OR). First, the theory and application of linear programming (LP) is presented. Students will learn the underlying principles (Optimization, Duality, Simplex) and solve exercises in the context of agricultural production. In the second part of the course, the foundation of non-linear programming (NLP) is introduced (Lagrangian, Kuhn-Tucker) and illustrated with various examples.</td>
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<tr>
<td>Content</td>
<td>- Vorlesung Einführung in die Mikroökonomie - Grundkenntnisse der Ökonomie/Agrarökonomie</td>
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<td>Method-specific Competencies: Decision-making</td>
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<td>363-0537-00L</td>
<td>Resource and Environmental Economics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>A. Miftakhova, A. Minabutdinov</td>
</tr>
<tr>
<td>Abstract</td>
<td>Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems. A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.</td>
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<tr>
<td>Objective</td>
<td>Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems. A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.</td>
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<td>Personal Competencies: Problem-solving</td>
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</table>
Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power.

When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature


Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Method-specific Competencies</th>
<th>Techniques and Technologies</th>
<th>Concepts and Theories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessments</td>
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</tr>
</tbody>
</table>

Abstract

Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior.

Objective

Students will be able to:
- explain the decision-making processes underlying the purchasing process
- describe the factors that have an influence on consumer behavior
- develop strategies to influence purchasing behavior

Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies

Method-specific Competencies
- Decision-making

Social Competencies
- Cooperation and Teamwork
- Customer Orientation
- Sensitivity to Diversity

Personal Competencies
- Critical Thinking

Abstract

Agriculture needs to become more sustainable via innovative approaches. This course allows students to explore in group work, how this could be realized. There are short impulse talks on ‘Smart Farming’ given by experts on technology, sustainability and entrepreneurship. Most importantly, students elaborate the first steps to create a startup company in this field.

Objective

During the course, the students generate their own ideas. They explore e.g., which technologies provide possibilities for a more sustainable agriculture. They simulate the creation of a startup company in a team.

Prerequisites / notice

All students interested should come to the first lecture (25th September). There, details of this year’s format will be explained. If case students are then still interested to visit the class, they have to write a motivational letter of max. 100 words and send it via email to Achim.Walter@usys.ethz.ch until (27.9.). Participants will be selected according to the following criteria:
1.) Convincing motivational letter
2 a) Agricultural science students of the BSc program, 5. Semester
2 b) Students of other semesters or study programs, who will be selected with a view to forming four interdisciplinary and diverse teams. The definitive acceptance to the course will be communicated to students by (27.9.). The definitive inscription will subsequently been done by the study secretariate.

Number of participants limited to 16.
Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

**Week 1**
The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

**Week 2**
Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

**Week 3**
Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

**Week 4**
Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytopoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

**Week 5**
Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

**Week 6**
Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.

**Week 7**

**Week 8**
Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

**Week 9**
Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

**Week 10**
Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.

**Week 11**

**Week 12**

**Week 13**
Cultural control methods: fertilizers, crop rotations.

**Week 14**
Open lecture.

Lecture notes

Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.
Abstract
This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

Objective
(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content
The course will address a wide range of agricultural and food system challenges (e.g. food security, climate crisis, soil degradation, etc.) in both temperate and tropical contexts. In class we will address topics like building food system resilience through innovative measures, improving soil fertility management or understanding the effects of agroforestry systems. Case studies from the on-going research in the Sustainable Agroecosystems Group (sa.e.ethz.ch) will be presented, covering different scales (e.g. food value-chains, farm dynamics and soil management).

The class is complemented by practical group work conducted with the CSA Meh Alis Grandma in Zürich on Measuring and monitoring Agroecological performance.

Students will gain an overview on institutions and actors' roles in the field of sustainable agricultural development. Throughout the group work, students will learn to engage directly with various stakeholders, monitor agroecological transition and communicate their research to a wider audience. Ultimately, this class should provide an overview on methods, tools, innovations and platforms that support a sustainable food transformation.

Literature

Prerequisites / notice
Prior participation in the lecture Nachhaltige Agrärökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed
Project Management fostered

Method-specific Competencies
Communication fostered
Cooperation and Teamwork assessed
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Social Competencies

Personal Competencies

751-7103-00L

Abstract
The basics of planning of feeding and formulation of diets incl. the implications on nutrient cycles and balances are taught. In the part dealing with ruminants, forage-based diets and the application of feed formulation programs are central and exercised on-farm. With pigs and poultry, the basics of energy and nutrient requirements are deepened through practical examples.

Objective
The students are able, based on the knowledge they obtain in this course, to deal with problems in the nutrition of ruminants, pigs and poultry on farm.

Content
- Programmteil Wiederkäuer: Einführung in die Winterfütterungsplanung für Milchkühe, Betriebsbesuch (Erfassung aller notwendigen Daten inkl. Futterprobenentnahme für eine konkrete Planung auf einem Praxisbetrieb), Besonderheiten der Milchviehfütterung (Laktationsverlauf, Jahreszeit, etc.); Einführung in den LBL-Fütterungsplan, Möglichkeiten der Futterbeurteilung und -bewertung mit praktischer Beurteilung der gesammelten Proben, Berechnungen und Besprechung des Fütterungsplanes.
- Programmteil Nicht-Wiederkäuer: Der Energie- und spezifische Nährstoffbedarf beim Schwein und Geflügel; Besonderheiten der Fütterung in den verschiedenen Produktionsphasen; Fütterungsempfehlungen und -hinweise. Rationengestaltung und Rezeptoptimierung für Mischfuttermittel anhand verschiedener Beispiele; Einsatzzgrenzen von Futtermittel; technologische Futterbearbeitung.

Lecture notes
Handouts in German language will be provided by each lecturer on the Moodle platform when starting his part of the lecture.

Literature
The Dozierenden geben in der Lehrveranstaltung die relevante Literatur bekannt.

Competencies
Social Competencies

Cooperation and Teamwork fostered

751-7103-00L
Animal Feed and Feeding of Ruminants W 2 credits 2V M. A. Boessinger, M. Rombach

Abstract
The knowledge of the nutrition of ruminants and of the feeds used is deepened. Particular emphasis is put on the variety of home-grown feeds, their production and conservation and their application in the nutrition of dairy cows, cattle and small ruminants. Finally, information on specific problems of animal nutrition is communicated.

Objective
Purchase of basic skills in agricultural livestock nutrition.

Content

Lecture notes
Script is available in German language and will be provided by each lecturer when starting his part the lecture.

Literature
Eine Literaturliste ist im Skript enthalten.

Prerequisites / notice
Fach mit benoteter Prüfung am Ende der Lehrveranstaltung.
Agroecology is a discipline, an agricultural practice, and a political-social movement. Students will attend public lectures by experts from different fields and will reflect on agroecology and its principles. Moreover, students will expand their knowledge with case studies and discuss about the role of agroecology to support sustainable agriculture and food systems.

Students are part of small groups focusing on selected principles of the HLPE. During the course, students discuss the potential and limitations of agroecology and learn about scientific contributions to agroecology. Students form an opinion on the role of agroecology, reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

The course is designed as a combination of public lectures/webinars on “Agroecology and the Transformation to Sustainable Food Systems” delivered by national and international experts and scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a group work format. The public lectures bring different perspectives to the discussion and are intended as inputs for the students’ sessions. In the student sessions, the student groups deepen their knowledge of the 13 principles of agroecology proposed by the High-Level Panel of Experts (HLPE) of the Committee on World Food Security. They identify “unknowns” and link to other closely related principles. The groups also work out the perspective of a chosen stakeholder. Finally, the groups will take part in a scientific discussion representing their stakeholder perspective. All groups will synthesize their discussions in a short report.

Handouts will be available on the webpage of the course.
Literature


Report of HLPE on agroecology:

Prerequisites / notice

This course is based on fundamental knowledge about plant ecophysiology, soil science, biogeochemistry, crop and forage science, and ecology in general. The course will be taught in English. The course is only offered in fall.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
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Competencies

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Bachelor's Thesis

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-1020-10L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>14 credits</td>
<td>30D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract

Die Bachelorarbeit stellt den Abschluss des Bachelorstudiums dar. Sie ist eine wissenschaftliche und selbständige Arbeit unter der Leitung einer Dozentin oder eines Dozenten der Studienrichtung Agrarwissenschaft.

Objective

Selbständiges Verfassen einer wissenschaftlichen Arbeit.

Content

Verfassen einer wissenschaftlichen und selbständigen Arbeit unter der Leitung einer Dozentin oder eines Dozenten der Studienrichtung Agrarwissenschaft.

Agricultural Sciences Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
In this class, students will learn concepts and skills for coping with psychosocial demands of teaching. The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is mandatory.

Abstract
This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Objective
Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content
Thematic Schwerpunkte:
- Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:
- Get information about recent literature on learning and instruction
- Understanding findings relevant for education
- Getting to know intelligence tests
- Understanding findings relevant for education

Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

Abstract
This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

Abstract
This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Abstract
The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite.

Objective
- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma*" or "Didaktisches Zertifikat*. It is about learning in childhood and adolescence.

Abstract
This course aims to inform students on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma*" or "Didaktisches Zertifikat*. It is about learning in childhood and adolescence.

Abstract
This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma*" or "Didaktisches Zertifikat*. It is about learning in childhood and adolescence.

Abstract
This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma*" or "Didaktisches Zertifikat*. It is about learning in childhood and adolescence.

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Objective
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Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma*" or "Didaktisches Zertifikat*. It is about learning in childhood and adolescence.

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Prerequisites / notice
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Abstract
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Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma*" or "Didaktisches Zertifikat*. It is about learning in childhood and adolescence.
Die Studierenden sammeln Erfahrungen in der Unterrichtsführung, der Auseinandersetzung mit Lernenden, der Klassenbetreuung und der mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Teaching Internship Including Examination Lessons</td>
<td>W</td>
<td>6 credits</td>
<td>13P</td>
</tr>
</tbody>
</table>

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.

- Students are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

The teaching internship can just be visited if all other courses of TC are completed.

Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

<table>
<thead>
<tr>
<th>Competencies</th>
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<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentored Work Subject Didactics Agricultural Science</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
</tr>
</tbody>
</table>

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.
Objective
The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content
Thematische Schwerpunkte:

Lernformen:

Lecture notes
Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>assessed</td>
<td>Customer Orientation</td>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
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</tr>
<tr>
<td>Decision-making</td>
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<td>Adaptability and Flexibility</td>
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<tr>
<td>Creative Thinking</td>
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Agricultural Sciences TC - Key for Type

<table>
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<tr>
<th>Key for Type</th>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
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Key for Hours

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</thead>
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<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
Agricultural Sciences Master
► Major in Animal Sciences
► Disciplinary Competences
►► LivestockSystems

<table>
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<tr>
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<th>Hours</th>
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<tr>
<td>751-6501-00L</td>
<td>Ruminant Science</td>
<td>W+</td>
<td>4</td>
<td>4G</td>
<td>M. Niu, M. Terranova, U. Witschi</td>
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**Abstract**
The course provides the scientific basis of the central aspects of reproduction and nutrition physiology of ruminants, and of the implications for animal health, product quality, and breeding programs. Means of knowledge transfer include interdisciplinary approaches, disciplinary parts, web-based learning and self-study.

**Objective**
At the end of the course the students are able to apply, by a comprehensive understanding of the underlying mechanisms, their knowledge in various fields of ruminant science. They will be able to develop and recommend best strategies for breeding programs, feed formulation, improving forage quality, and increasing animal health. They will be trained to carry out interdisciplinary and disciplinary research at the highest level.

**Content**
Fields (contact hours)
- Introduction: 2 h
- Special topics: 20 h
  - Rumen Anatomy
  - Hohenheim Gas Test
  - Calf health
  - Reproduction Techniques
  - Fertility in Cows
- Disciplinary topics: 32 h
  - Ruminal Digestion: 8 h
  - Ruminant Nutrition Physiology: 12 h
  - Reproduction in Ruminants: 8 h
- Lectures held by the students: 4 h

In summary
- Contact hours: 58 h
- Self-study within semester: 30 h (especially preparation for the interdisciplinary courses and the own lecture)
- Self-study in semester break: 32 h
Total: 120 h

**751-6001-00L**
Forum: Livestock in the World Food System

**Abstract**
This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.

**Objective**
In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society).

The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Furthermore, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.

**Content**
The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

**Part 1**
Aspect 1 - Oral presentation: The students form small groups and are lecturers.
Aspect 2 - chairperson: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

**Part 2**
Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

**Lecture notes**
no scriptum

**Prerequisites / notice**
Requirements for allocation of the two credit points:
- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)
- feedback on the presentation style of a student

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751-2105-00L  
Political Ecology of Food and Agriculture  

Number of participants limited to 25  
A motivational application is required:  
- presenting yourself and your studies  
- stating what topic in the field of Political Ecology that you are interested in  
- suggesting one paper to enrich the literature list for the course  

Questions regarding the application to johanna.jacobi@usys.ethz.ch.

Abstract  
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

Objective  
- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment  
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes  
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

Content  
We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

Lecture notes  
20.9.2024 Introduction to political ecology  
27.9.2024 Ontologies and epistemologies  
4.10.2024 Green revolution, industrial agriculture, and agroecology  
11.10.2024 Don't blame the rain: Water management in agriculture  
18.10.2024 Climate justice and food systems  
25.10.2024 Conservation: Protecting what from what?  
8.11.2024 Deforestation: Root causes and alternatives  
15.11.2024 Technology and the politics of knowledge  
22.11.2024 Land-sharing, land-sparing  
29.11.2024 Feminist (political) agroecology  
6.12.2024 Food: Commons or commodity?  
13.12.2024 Alternatives to sustainable development  
20.12.2024 Final session (The Hunger Banquet)

Literature  
Literaturelist provided on Moodle when the course starts.

https://moodle-app2.let.ethz.ch/course/view.php?id=20544

Competencies  
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<td>Self-awareness and Self-reflection</td>
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Livestock Biology

Number  Title  Type  ECTS  Hours  Lecturers
751-6113-00L  Endocrinology and Biology of Reproduction  W+  3 credits  2G  S. E. Ulbrich, S. M. Bernal Ulloa

Abstract  
Endokrinologie und Reproduktionsbiologie der Säugetiere und des Menschen (Anatomie, Morphologie, Physiologie, Regelmechanismen) Die Systematik der Reproduktionshormone und der Hormonrezeptoren wird erläutert, die Wirkungsmechanismen (Bildung; orale Bioverfügbarkeit; Elimination) erklärt. Mit diesen Grundlagen wird das Verständnis der Regulation der Fortpflanzung umfassend erörtert.

Objective  
Die Studierenden erlangen das grundlegende theoretische Verständnis und Fachwissen zur Endokrinologie der Reproduktion und zur weiblichen und männlichen Reproduktionsbiologie. Sie können darüber hinaus pathologische Situationen (Fortpflanzungsstörungen) und deren vielfältige Ursachen in den physiologischen Kontext einordnen.
Learning Objectives: Part 1:
Swiss routine breeding value estimation/genetic evaluation systems of cattle, pig, sheep and goats are presented with methods and
The teaching slides and other materials will be provided during the course.
This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific
The course gives an introduction into different classes of bioactive components present in food and feed including fatty acids and
fostered
assessed
H. Signer-Hasler
Type
Lecturers
Papers will be assigned and downloaded from a web page announced during the lecture.
The course provides students with the basic knowledge to understand the connection between the structure of nutritive and non-nutritive
bioactive food and feed components and their effects on the nutrient supply and health of humans and livestock as well as on the quality of
animal-derived foods.
Objective
At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive
understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their
knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.
Content
The course gives an introduction into different classes of bioactive components present in food and feed including fatty acids and
secondary plant compounds such as carotenoids, polyphenols, phytoestrogens, glucosinolates, protease inhibitors and monoterpenes.
Topics include:
- sources of bioactive food and feed components
- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

Lecture notes
The teaching slides and other materials will be provided during the course.

Literature
Information about books and other references will be communicated during the course.

701-0263-01L Seminar in Evolutionary Ecology of Infectious Diseases W+ 3 credits 2G R. R. Regös, S. Bonhoeffer
Abstract
Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student
chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will
change from year to year corresponding to the progress and new results occurring in the field.
Objective
This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific
literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.
Content
A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence,
resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and
tungi. Hosts will include animals, plants and humans.
Lecture notes
Publications and class notes can be downloaded from a web page announced during the lecture.

751-6243-00L Breeding and Conservation of Animal Genetic Resources W+ 2 credits 2V H. Signer-Hasler, C. Flury, H. Pausch
Abstract
Animal genetic resources refer to the genetic and species diversity of livestock. Only a few production breeds have been further developed
through breeding, while local breeds have no longer been able to survive in this competition. Without the support of endangered breeds
and the sustainable breeding of productive breeds, many regionally typical breeds are threatened with extinction.
Objective
Learning Objectives: Part 1:
At the end of the course, students are able to assess the importance and problems of small ruminant breeding and husbandry in
Switzerland and neighbouring countries. They know the most important breeding objectives and are able to assess them in terms of
production and sustainable development in small ruminants and cattle.
Learning objectives part 2:
The second part gives an overview of the distribution, endangerment and conservation of breed diversity of farm animals in Switzerland
and internationally. The theory is illustrated with numerous examples and the knowledge is deepened in exercises.
The students:
- have an overview of the national and international distribution of animal genetic resources and are familiar with the database DAD-IS
(Domestic Animal Diversity Information System).
- can name the national and international efforts to conserve agricultural livestock breeds.
- know how to describe genetic diversity.
- know the challenges in the management of small populations.
- can describe different conservation measures, especially in situ and ex situ conservation.
- can describe current national and international conservation programmes for different livestock breeds.
Prerequisites / notice
Examination:
Examination Part 1: Graded written examination (1 hour) on the material covered.
Examination Part 2: Graded semester performance completed during the block course.
Parts 1 and 2 contribute equally to the final grade.

751-6305-00L Livestock Breeding and Genomics W 3 credits 3G P. von Rohr
Abstract
Swiss routine breeding value estimation/genetic evaluation systems of cattle, pig, sheep and goats are presented with methods and
evaluated traits. Examples will be demonstrated using the statistical software R.
Objective
The students know the theoretical and practical application of breeding value estimation in Switzerland for cattle, pig, sheep and goats. The
students are able to interpret estimated breeding values.
The course program uses a learning-by-doing approach ("hands-on minds-on"). The topics are introduced as short lectures, but most of the
Experimental Design and Applied Statistics in
Subject-specific Competencies
A. Hund
assessed
basic principles of genetic evaluations
Applied genetic evaluation in cattle (data, methods, traits, national and international genetic evaluations)
Applied genetic evaluation in pigs (data, methods, traits)
Applied genetic evaluation in sheep and goats (data, methods, traits)

Lecture notes
Course notes in the form of a monograph, copies of the slides and solutions to the exercise questions are available.

Literature
To be announced in the lectures.

 Competencies

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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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Social Competencies
Cooperation and Teamwork
Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Self-direction and Self-management

Methodology Competences

Methods for Scientific Research

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<tr>
<th>Number</th>
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<td>Agroecosystem Science</td>
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<td>A. Hund, C. Grüder, R. Kölliker</td>
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</table>

Abstract
Different experimental designs will be discussed and various statistical tools will be applied to research questions in agroecosystem
sciences. Statistical methods range from simple analysis of variance to mixed-models and multivariate statistics. Surveys and manipulative
field and laboratory experiments are addressed and students learn to analyse data using a hands-on approach.

Objective
Students will know various statistical analyses and their application to science problems in their study area as well as a wide range of
experimental design options used in environmental and agricultural sciences. They will practice to use statistical software packages (R),
understand pros and cons of various designs and statistics, and be able to statistically evaluate their own results as well as those of
published studies.

Content
The course program uses a learning-by-doing approach ("hands-on minds-on"). The topics are introduced as short lectures, but most of the
work is done on the computer using different packages of R – a software for statistical calculation and graphics. In addition to contact hours
exercises must be finalized and handed in for grading. The credit points will be given based on successful assessments of selected
exercises.

The tentative schedule contains the following topics:
- Introduction to experimental design and applied statistics in R
- Data handling and data exploration with tidyverse
- Designs of field and growth chamber experiments theory
- Design creation with DiGGer
- Fitting linear mixed-effects models with lme4
- Marginal means estimation and post-hoc tests with emmeans
- Nonlinear regression fits
- Statistical learning techniques
- Principle component analysis, canonical correspondance analysis (CCA), cluster analysis
- Random forest

This course does not provide the mathematical background that students are expected to bring along when signing up to this course.
Alternatively, students can consider some aspects of this course as a first exposure to solutions in experimental design and applied
statistics and then deepen their understanding in follow-up statistical courses.

Lecture notes
Handouts will be available (in English)

Literature
A selection of suggested additional literature, especially for German speaking students will be presented in the introductory lecture.

Prerequisites / notice
This course is based on the course Mathematik IV: Statistik, passed in the 2nd year and the Bachelor's course "Wissenschaftliche
Datenauswertung und Datenpräsentation" (751-0441-00L)

Competencies

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751-6003-00L Training Course in Research Groups (Large)

Abstract
The students will learn the conceptual and methodological background of research in the animal science groups of the Institute of Plant,
Animal and Agroecosystem Sciences. In addition to teaching the theoretical background, the major aim of the course is to integrate the
students into the research groups (on job training) and, hence, to focus on the practical application of the knowledge.

Objective
- Introduction into the conceptual and methodological basis of research
- Integration of the students into the research groups (on job training)
- Application of the gained knowledge

Content
The students will be integrated into the research groups day-to-day work and will thus deal with all aspects of scientific work. This
comprises the planning (conceptually and logistically), execution (data collection, laboratory analyses) and evaluation (statistics, data
presentation) of experiments as well as the basics of scientific writing (aim: later publication, Master thesis). The research topics and the
range of methodologies vary between the animal science research groups in the Institute of Plant, Animal and Agroecosystem Sciences.

Lecture notes
None

Literature
Specific readings after enlisting in a particular research group.
Prerequisites / notice
The number of training slots in the various groups is limited. It is therefore highly recommended to contact the group leaders early enough (first come first serve).
The full integration in a research group often means to work on weekends.
The total time budget is equivalent to about 180 hours. Active participation in group meetings (discussion, presentation) and short written reports about the work conducted are required for the 6 credit points. There are no grades, it is only pass or fail.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management


Abstract
The students will learn the conceptual and methodological background of research in the animal science groups of the Institute of Plant, Animal and Agroecosystem Science. In addition to teaching the theoretical background, the major aim of the course is to integrate the students into the research groups (on job training) and, hence, to focus on the practical application of the knowledge.

Objective
- Introduction into the conceptual and methodological basis of research
- Integration of the students into the research groups (on job training)
- Application of the gained knowledge

Content
The students will be integrated into the research groups day-to-day work and will thus deal with all aspects of scientific work. This comprises the planning (conceptually and logistically), execution (data collection, laboratory analyses) and evaluation (statistics, data presentation) of experiments as well as the basics of scientific writing (aim: later publication, Master thesis). The research topics and the range of methodologies vary between the animal science research groups in the Institute of Plant, Animal and Agroecosystem Sciences.

Lecture notes
None

Literature
Specific readings after enlisting in a particular research group.

Prerequisites / notice
The number of training slots in the various groups is limited. It is therefore highly recommended to contact the group leaders early enough (first come first serve).
The full integration in a research group often means to work on weekends.
The total time budget is equivalent to about 90 hours. Active participation in group meetings (discussion, presentation) and short written reports about the work conducted are required for the 3 credit points. There are no grades, it is only pass or fail.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Project Management for Scientific Research

Number Title Type ECTS Hours Lecturers
751-6001-00L Forum: Livestock in the World Food System W+ 2 credits 2S S. Meese

Abstract
This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.

Objective
In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.
The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

Part 1
Aspect 1 - Oral presentation: The students form small groups and are lecturers.
Aspect 2 - chairperson: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

Part 2.
Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Introductions to both presentation forms will be given by the lecturer.

Lecture notes
no scriptum

Prerequisites / notice
Requirements for allocation of the two credit points:
- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)
- feedback on the presentation style of a student

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<th>Tropical Cropping Systems, Soils and Livelihoods (with Excursion)</th>
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751-5201-10L W+ 5 credits 10G J. Six, K. Benabderrazik

Abstract
This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in the Mount Kenya Region, which is co-organized with the University of Embu (Kenya).

Objective
(1) Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
(2) Interdisciplinary analysis of agricultural production systems
(3) Knowledge on methods to assess agroecological performance of a tropical agroecosystems
(4) Hands-on training on the use of field methods, diagnostic tools and survey methods.
(5) Gain practical knowledge on how to assess to climate resilience and farming systems.
(6) Collaboration in international students and stakeholders

Content
This course guides students in analyzing and comprehending tropical agroecosystems. Students of ETH Zürich will work together with the students from Embu University (Kenya) in an interdisciplinary and intercultural team. Students will focus on the Agroecological performance and climate resilience of diverse farming systems in the Mount Kenya Region.

From October 28th to November 11th, The students will take part in a field course in the Mount Kenya Region. Students will then gain practical knowledge on field, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

Prerequisites / notice
We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 18rd 2023, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

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<td>Self-awareness and Self-reflection</td>
<td>Self-direction and Self-management</td>
<td>Integrity and Work Ethics</td>
<td>Self-awareness and Self-reflection</td>
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<td>assessed</td>
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</table>

IMPORTANT: Students who enroll for this course are strongly recommended to verify with lecturers from other courses whether their absence of two weeks may affect their performance in the respective courses.
## Alternative Crops

**Number** 751-4104-00L  
**Title** Alternative Crops  
**Type** W+  
**ECTS** 2 credits  
**Hours** 2V  
**Lecturers** A. Walter, K. Berger Büter

### Abstract
Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

### Objective
During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Media and Digital Technologies
- Problem-solving
- Project Management

**Method-specific Competencies**
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity

**Social Competencies**
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Personal Competencies**
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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## Current Challenges in Plant Breeding

**Number** 751-3603-00L  
**Title** Current Challenges in Plant Breeding  
**Type** W+  
**ECTS** 2 credits  
**Hours** 2G  
**Lecturers** B. Studer, A. Hund, R. Kölliker

### Abstract
The seminar 'Current Challenges in Plant Breeding' aims to bring together national and international experts in plant breeding to discuss current activities, latest achievements and future prospective of a selected topic/area in plant breeding.

### Objective
The educational objectives cover thematic, methodic as well as social and personal competencies:
- Deepening of scientific knowledge in plant breeding
- Critical evaluation of current challenges and new concepts in plant breeding
- Promotion of collaboration and Master thesis projects with practical plant breeders

**Social/personal competencies:**
- Independent literature research to get familiar with the selected topic
- Establishment of a scientific presentation in an interdisciplinary team
- Establishing contacts and strengthening the network to national and international plant breeders and scientist

### Content
Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).

### Lecture notes
None

### Literature
Peer-reviewed research articles, selected according to the topic.

### Prerequisites / notice
Participation in the BSc course ‘Pflanzenzüchtung’ is strongly recommended, a completed course in ‘Molecular Plant Breeding’ is advantageous.

### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Creativity
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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## Weed Science

**Number** 751-4704-00L  
**Title** Weed Science  
**Type** W+  
**ECTS** 3 credits  
**Hours** 2G  
**Lecturers** B. Streit, U. J. Haas

### Abstract
Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops.

### Objective
At the end of the course the students are qualified to develop sustainable solutions for weed problems in agricultural and natural habitats.

### Content
Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops. Accordingly, this knowledge will be imparted during the course and will be required to understand the mechanisms of integrated weed control strategies.
### Crop Health

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-5121-00L</td>
<td>Insect Ecology</td>
<td>W+</td>
<td>2</td>
<td>2V</td>
<td>C. De Moraes, N. Stanczyk</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This is an introductory class on insect ecology. During the course you will learn about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes in-person lectures, small group discussions and outside readings.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The aim of the course is for you to be able to describe examples of insect interactions and evaluate their impact on broader ecosystems. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutual and parasitic interactions, and examining insect ecology in an evolutionary context.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Provided to students through Moodle. Optional recommended readings with additional information.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Selected required readings (peer reviewed literature).</td>
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<td><strong>Competencies</strong></td>
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<td>Social Competencies: Communication fostered</td>
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<td>Cooperation and Teamwork fostered</td>
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<td>Personal Competencies: Critical Thinking assessed</td>
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<tr>
<td>751-4811-00L</td>
<td>Alien Organisms in Agriculture</td>
<td>W+</td>
<td>2</td>
<td>2G</td>
<td>J. Collatz, M. Meissle</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Students will understand the consequences arising from the unintentional or deliberate introduction of alien organisms into agricultural systems. They will be able to understand the concept of environmental risk assessment and be able to evaluate risk management options.</td>
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<td><strong>Objective</strong></td>
<td>Alien organisms in agriculture is a topic that receives an increasing awareness among farmers, agricultural scientists, regulators and the general public. Students of this course will learn about the nature of alien organisms such as invasive species, biocontrol organisms and genetically modified organisms. With a particular focus to understanding plants and their interactions we will look at the potential threats the novel organisms pose, the benefits they provide and how both of these effects can be scientifically assessed. Students will learn how the topic of alien organisms in agriculture is intrinsically tied to policy making and regulation and get to know current examples and future challenges in research. In the last part of the course students will be able to apply the acquired knowledge in a practical exercise (case study).</td>
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<td><strong>Lecture notes</strong></td>
<td>Material will be distributed during the course</td>
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<td><strong>Prerequisites / notice</strong></td>
<td>A part of the course will take place in flipped classroom mode, i.e. some lectures will be available as podcasts.</td>
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<td><strong>Competencies</strong></td>
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<td>Decision-making assessed</td>
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<td>Social Competencies: Communication assessed</td>
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<td>Cooperation and Teamwork assessed</td>
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<td>Personal Competencies: Critical Thinking assessed</td>
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<td>Self-direction and Self-management fostered</td>
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<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.</td>
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<td><strong>Objective</strong></td>
<td>This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.</td>
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<td><strong>Content</strong></td>
<td>A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.</td>
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<td><strong>Lecture notes</strong></td>
<td>Publications and class notes can be downloaded from a web page announced during the lecture.</td>
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<td><strong>Literature</strong></td>
<td>Papers will be assigned and downloaded from a web page announced during the lecture.</td>
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<td><strong>Competencies</strong></td>
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<td>Leadership and Responsibility fostered</td>
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<td>Self-presentation and Social Influence fostered</td>
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<td>Sensitivity to Diversity fostered</td>
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<td>Negotiation fostered</td>
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<td>Personal Competencies: Adaptability and Flexibility fostered</td>
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<td>Critical Thinking fostered</td>
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<td>Self-awareness and Self-reflection fostered</td>
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<tr>
<td>751-4506-00L</td>
<td>Plant Pathology III</td>
<td>W+</td>
<td>2</td>
<td>2G</td>
<td>M. Maurhofer Bringolf</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Identification based on host, symptoms and micro-morphology, completed with life cycles and related control measures of the most important fungal diseases and their causal pathogens of annual and perennial crops with agricultural significance.</td>
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<td><strong>Objective</strong></td>
<td>The students will learn and train preparation skills for microscopy, aquire knowledge of selected diseases (identification, biology of pathogen, epidemiology and systematics) and understand the corresponding integrated control measures practiced in Swiss agriculture.</td>
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<td><strong>Content</strong></td>
<td>One exercise will be based on computer and ocular camera, also to prepare the students for the final e-exam.</td>
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<td><strong>Lecture notes</strong></td>
<td>A script will be used on annual and perennial crops and their most important diseases. It will be updated stepwise</td>
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<td><strong>Prerequisites / notice</strong></td>
<td>The course will be in German (spec. nomenclature)</td>
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### Agriculture and Environment

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<tr>
<td>751-5101-00L</td>
<td>Biogeochemistry and Sustainable Management</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>I. Feigenwinter, N. Buchmann, K.-M. Kohonen</td>
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</table>

**Abstract**
This course focuses on the interactions between ecology, biogeochemistry and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems.

**Objective**
Students will analyse and understand the complex and interacting processes of ecology, biogeochemistry and management of agroecosystems. They will use their theoretical knowledge in two flipped classroom exercises, but also set up a small weather station and program a data logger to collect meteorological variables, analyze large meteorological and flux data sets, and evaluate the impacts of weather events and management practices on the ecosystem greenhouse gas exchange. Thus, students will expand their computational competences. Moreover, students will be able to coordinate and work successfully in small (interdisciplinary) teams.

**Content**
Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact on any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere-interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

Students will gain profound knowledge about biogeochemical cycles and greenhouse gas fluxes in managed grassland and/or cropland ecosystems as well as expand their computational competences. Responses of agroecosystems to the environment, i.e., to climate and weather events, but also to management will be studied. Two flipped class-room exercises include the assessment of an ecosystem disturbance and the experimental design of an own study. Dataloggers will be programmed, and a small weather station will be set up. Different meteorological and greenhouse gas flux data will be analysed (using R) and assessed in terms of production, greenhouse gas budgets, and carbon sequestration. Thus, students will learn how to collect, analyse and interpret data about the complex interactions of a coupled human-environmental system.

Students will work in groups (3-4 persons per group) with data from a small weather station (dedicated to the course), as well as data from the long-term measurement network Swiss FluxNet and from global databases. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

**Lecture notes**
Handouts will be available in moodle.

**Prerequisites / notice**
Prerequisites: Attendance of introductory courses in plant ecophysiology, ecology, and grassland or forest sciences. Knowledge of data analyses in R and statistics. Course will be taught in English.

**Competencies**

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<th>Social Competencies</th>
<th>Cooperation and Teamwork</th>
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<tr>
<th>Personal Competencies</th>
<th>Critical Thinking</th>
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<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>751-3405-00L</td>
<td>Chemical Nature of Nutrients and their Availability to Plants: The Case of Phosphorus</td>
<td>W+</td>
<td>4 credits</td>
<td>4G</td>
<td>E. Frossard</td>
</tr>
</tbody>
</table>

**Abstract**
The CNNAP course discusses the mechanistic relationships between nutrient speciation in fertilizer and nutrient uptake by plants using phosphorus as an example. The course involves theoretical aspects of nutrient cycling, laboratory work, data analysis and presentation, and the use of advanced methods in plant nutrition studies.

**Objective**
At the end of the CNNAP course, participants will obtain a mechanistic understanding of why and how the speciation of phosphorus in fertilizer can affect its release to the soil solution and subsequent uptake by plants. Students will be able to use this information for the development of fertilization schemes that maximize the nutrient uptake and fertilizer efficiency of crops or pastures. During the course, participants will become familiar with the use of radioisotopes and nuclear magnetic resonance as approaches to measure nutrient availability and forms, respectively and they will know the limits of these techniques. Students will also have the opportunity to improve their laboratory, presentation, discussion and writing skills.

**Lecture notes**
Documents will be distributed during the lecture.

**Literature**
Documents will be distributed during the lecture.

**Prerequisites / notice**
The CNNAP lecture will take place at the ETH experimental station in Eschikon Lindau every second year. The next course will be organized in autumn 2024. The CNNAP course will take place if and only if 8 or more students are registered one week before the start. See the location of the station at: http://www.plantnutrition.ethz.ch/the-group/how-to-find-us.html

We strongly advise students who are planning to be absent for more than one week during the semester NOT to visit this course. Students should have visited the plant nutrition lectures in the 3rd and 6th semesters and the lecture pedosphere in the 3rd semester of the agricultural study program of the ETH. If students do not have visited these courses they will have to acquire the necessary information by themselves as this knowledge is indispensable for the CNNAP course. As the CNNAP course does not take place in autumn 2023, we recommend students interested in integrated assessment of nutrient cycling in soil plant systems to visit the 8th semester lecture 751-3404-00L (Nutrient Fluxes in Soil-Plant Systems: The Case of Nitrogen) organized in spring 2024 by Oberson et al.
This course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions. Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small IsoProject, practice to search and analyze literature as well as to give an oral presentation. This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises. 

Lecture notes
Handouts will be available on the webpage of the course.

Literature
Will be discussed in class.

Prerequisites / notice
This course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.

Competencies
| Subject-specific Competencies | Concepts and Theories | assessed |
| Method-specific Competencies | Analytical Competencies | assessed |
| Social Competencies | Communication | assessed |
| Personal Competencies | Adaptability and Flexibility | fostered |

Methodology Competences
Seminar in Plant Sciences

Number Title Type ECTS Hours Lecturers
751-5115-00L Current Aspects of Nutrient Cycle in Agro-Ecosystems W+ 2 credits 1S E. Frossard, A. Oberson Dräyer

Abstract
The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is "Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments". Analyze publications and/or data records on long-term field experiments regarding their content on integrated nutrient management and derive the nutrient use efficiency; link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems. The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is "Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments". The students will analyze and connect the results published (or from data records) for selected field experiments in a group work. They will present their analysis in a report and in an oral presentation. The seminar is composed by presentations of experts and of the students. The presentations will be synthesized during a final discussion.
## Critical Thinking

- Communication
- assessed

## Communication

- fostered

## Subject-specific Competencies

- fostered

## Social Competencies

- Communication
- assessed

## Personal Competencies

- Adaptable and flexibility
- fostered

## Analytical Competencies

- Critical Thinking
- assessed

## Method-specific Competencies

- Analytical Competencies
- assessed

## Competencies

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<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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<td>Personal Competencies</td>
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## 751-4003-01L Current Topics in Grassland Sciences (autumn)  

- W+ 2 credits 2S  
- N. Buchmann

### Abstract

Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as by doctoral and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

### Objective

- Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.

### Content

- Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as by doctoral and graduate students.
- Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

### Lecture notes notice

- none

### Prerequisites / Competencies

- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Communication assessed
- Personal Competencies: Critical Thinking assessed

## 751-2105-00L Political Ecology of Food and Agriculture  

- W+ 3 credits 2G  
- J. Jacobi

### Number of participants limited to 25

A motivational application is required:

- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

### Questions regarding the application to

- johanna.jacobi@usys.ethz.ch.

### Abstract

In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

### Objective

- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

### Content

- We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools.
- For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production.
- Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice.
- While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

### Lecture notes

- 20.9.2024 Introduction to political ecology
- 27.9.2024 Ontologies and epistemologies
- 4.10.2024 Green revolution, industrial agriculture, and agroecology
- 11.10.2024 Don't blame the rain: Water management in agriculture
- 18.10.2024 Climate justice and food systems
- 25.10.2024 Conservation: Protecting what from what?
- 1.11.2024 Deforestation: Root causes and alternatives
- 8.11.2024 Pandemics, syndemics and the food system
- 15.11.2024 Technology and the politics of knowledge
- 22.11.2024 Land-sharing, land-sparing
- 29.11.2024 Feminist (political) agroecology
- 6.12.2024 Food: Commons or commodity?
- 13.12.2024 Alternatives to sustainable development
- 20.12.2024 Final session (The Hunger Banquet)

### Literature

- Literaturelist provided on Moodle when the course starts.

Design, Analysis and Communication of Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-3801-00L</td>
<td>Experimental Design and Applied Statistics in</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>A. Hund, C. Grieder, R. Kölliker</td>
</tr>
<tr>
<td></td>
<td>Agroecosystem Science</td>
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</table>

**Abstract**

Different experimental designs will be discussed and various statistical tools will be applied to research questions in agroecosystem sciences. Statistical methods range from simple analysis of variance to mixed-models and multivariate statistics. Surveys and manipulative field and laboratory experiments are addressed and students learn to analyse data using a hands-on approach.

**Objective**

Students will know various statistical analyses and their application to science problems in their study area as well as a wide range of experimental design options used in environmental and agricultural sciences. They will practice to use statistical software packages (R), understand pros and cons of various designs and statistics, and be able to statistically evaluate their own results as well as those of published studies.

**Content**

The course program uses a learning-by-doing approach ("hands-on minds-on"). The topics are introduced as short lectures, but most of the work is done on the computer using different packages of R – a software for statistical computing and graphics. In addition to contact hours exercises must be finalized and handed in for grading. The credit points will be given based on successful assessments of selected exercises.

The tentative schedule contains the following topics:

- Introduction to experimental design and applied statistics in R
- Data handling and data exploration with tidyverse
- Designs of field and growth chamber experiments theory
- Design creation with DiGGer
- Fitting linear mixed-effects models with lme4
- Marginal means estimation and post-hoc tests with emmeans
- Nonlinear regression fits
- Statistical learning techniques
- Principle component analysis, canonical correspondence analysis (CCA), cluster analysis
- Random forest

This course does not provide the mathematical background that students are expected to bring along when signing up to this course. Alternatively, students can consider some aspects of this course as a first exposure to solutions in experimental design and applied statistics and then deepen their understanding in follow-up statistical courses.

**Lecture notes**

Handouts will be available (in English)

**Literature**

A selection of suggested additional literature, especially for German speaking students will be presented in the introductory lecture.

This course is based on the course Mathematik IV: Statistik, passed in the 2nd year and the Bachelor's course "Wissenschaftliche Datenauswertung und Datenpräsentation" (751-0441-00L)

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Methods-specific Competencies</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</table>

**Prerequisites / notice**

Subjective Competencies

- Tropical Cropping Systems, Soils and Livelihoods (with Excursion)

**Objective**

This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in the Mount Kenya Region, which is co-organized with the University of Embu (Kenya)

**Content**

- Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
- Interdisciplinary analysis of agricultural production systems
- Hands-on training on the use of field methods, diagnostic tools and survey methods.
- Gain practical knowledge on how to assess to climate resilience and farming systems.
- Collaboration in international students and stakeholders

This course guides students in analyzing and comprehending tropical agroecosystems. Students of ETH Zürich will work together with the students from Embu University (Kenya) in an interdisciplinary and intercultural team. Students will focus on the Agroecological performance and climate resilience of diverse farming systems in the Mount Kenya Region.

From October 28th to November 11th. The students will take part in a field course in the Mount Kenya Region. Students will then gain practical knowledge on field, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

**Prerequisites / notice**

We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 18rd 2023, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.
Competencies | Subject-specific Competencies | Concepts and Theories | assessed
| | Techniques and Technologies | assessed
| Method-specific Competencies | Analytical Competencies | assessed
| | Decision-making | fostered
| | Problem-solving | fostered
| | Project Management | assessed
| Social Competencies | Communication | assessed
| | Cooperation and Teamwork | assessed
| | Leadership and Responsibility | assessed
| | Self-presentation and Social Influence | fostered
| | Sensitivity to Diversity | assessed
| | Negotiation | fostered
| Personal Competencies | Adaptability and Flexibility | assessed
| | Critical Thinking | assessed
| | Integrity and Work Ethics | assessed
| | Self-awareness and Self-reflection | assessed
| | Self-direction and Self-management | assessed

### Major in Agriculture Economics

#### Disciplinary Competences

#### Decision Making and Management

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0403-00L</td>
<td>Introduction to Marketing</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>F. von Wangenheim, P. Bachmann</td>
</tr>
<tr>
<td>751-2205-00L</td>
<td>Management for Enterprises in the Agri-Food-Chain II</td>
<td>W+</td>
<td>2 credits</td>
<td>2G</td>
<td>M. Weber</td>
</tr>
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*Data: 02.07.2024 12:39  Autumn Semester 2024  Page 37 of 2667*
Critical Thinking

Literature recommendations will be distributed via Moodle, and are available from the start of the course.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>Students</td>
<td>Corporate Sustainability is the flagship course of the Group for Sustainability and Technology at D- MTEC. In this course, students learn about key concepts in corporate sustainability and develop skills to implement them in the real world. The course prepares students for making well-informed sustainability decisions in their future careers.</td>
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<tr>
<td>Students</td>
<td>The course uses constructive alignment to bring the various innovative teaching and learning elements (e.g., case-based experiential learning, reflective thinking and blended learning with videos and quizzes) into a coherent transformational journey. Students can now flexibly, efficiently, and effectively access the conceptual foundations that are essential for a substantial understanding of corporate sustainability.</td>
</tr>
<tr>
<td>Students</td>
<td>For part of the course, students work in groups to complete a set of graded assignments designed to guide them into a deep dive on a selected corporate sustainability challenge. Please note that full participation in this part is essential, so make sure you are available. Furthermore, these group assignments count towards the overall grade for the course.</td>
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For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Resource Economics and Agricultural Policy

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>751-2903-00L</td>
<td>Evaluation of Agricultural Policies</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>R. Huber, R. Finger, C. Schader</td>
</tr>
</tbody>
</table>

Abstract

In this course, students get an overview of agricultural policy evaluations and their societal and political relevance. They learn to understand and apply the principles of scientific based evaluations of agricultural policies.

Objective

The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) They know the basics of how to design and implement a policy evaluation study. 3) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.). They make hands-on experiences of methodological challenges. 4) They can critically assess the science-policy interface of policy evaluations.

Content

The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.

Lecture notes

Handouts and reading assignments

Competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tr>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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Environmental Governance

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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-1651-00L</td>
<td>Environmental Governance</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>E. Lieberherr</td>
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</tbody>
</table>

Abstract

The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.
Objective
To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

To analyze the evolution as well as the key elements of environmental governance.

To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

Content
Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of 'environmental governance' and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Furthermore, we encourage the development of soft skills by engaging students in activities such as moderating discussions in class, presenting own proposals, giving regular peer feedback, as well as critically reflecting on various relevant publications in the environmental governance domain.

Lecture notes
Lecture slides, a script and additional course material will be provided on Moodle.

Prerequisites / notice
A detailed course schedule will be made available at the beginning of the semester.

During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)

Competencies

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Method-specific Competencies

- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Social Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
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Development and International Policy

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<th>Hours</th>
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<tr>
<td>751-2103-00L</td>
<td>Socioeconomics of Agriculture</td>
<td>W+</td>
<td>2</td>
<td>2V</td>
<td>S. Mann</td>
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</table>

Abstract
The main part of this lecture will examine constellations where hierarchies, markets or cooperation have been observed and described in the agricultural sector. On a more aggregated level, different agricultural systems will be evaluated in terms of main socioeconomic parameters like social capital or perceptions.

Objective
Students should be able to describe the dynamics of hierarchies, markets and cooperation in an agricultural context.

Content
Introduction to Sociology
Introduction to Socioeconomics
Agricultural Administration: Path dependencies and efficiency issues
Power in the Chain
The farming family
Occupational Choices
Market segregation
The issue of meat demand
Common Resource Management in Alpine Farming
Agricultural Cooperatives
Societal perceptions of agriculture
Perceptions of farming from within
Varieties of agricultural systems and policies

Lecture notes

Literature
see script

Prerequisites / notice
Basic economic knowledge is expected.
**International Development Cooperation**

*W+* 2 credits 2V  I. Günther

**Abstract**
The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.

**Objective**
Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid.

**Content**
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined.

**Literature**
Articles and book abstracts will be uploaded to a course website.

---

**International Environmental Politics**

*W+* 3 credits 2V  T. Bernauer

**Abstract**
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

**Lecture notes**
Reading materials and slides will be available via Moodle.

**Literature**
Reading materials and slides will be available via Moodle.

**Prerequisites / notice**
The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

**Credits and Exam**
After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.

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**Political Ecology of Food and Agriculture**

*W+* 3 credits 2G  J. Jacobi

**Abstract**
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

**Objective**
- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

**Content**
We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will stay from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.
Data has become an important resource in today's business environment, which can be used to make better management decisions. By the end of the course, students should understand the different existing approaches, their applicability, and their advantages and disadvantages. They should be able to read and understand regression output tables. Additionally, students will be able to apply the estimation approaches in practice using STATA.

Methodology Competences

Methods in Agricultural Economics

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<tr>
<td>363-0305-00L</td>
<td>Empirical Methods in Management</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Tillmanns</td>
</tr>
</tbody>
</table>

Abstract
In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evidence-based decision-making. The class includes assignments related to the lecture content.

Objective
The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

Content
Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understanding of statistical approaches. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature. Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics.

The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to that, there will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.

Literature
Literature and readings will be announced. For a basic understanding we recommend the Handbook of Good Research by Jürgen Brock and Florian von Wangenheim.

Prerequisites / notice
The course includes out-of-class assignments to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Assignments will be graded and need to be turned-in on time as they will be shown and discussed in class. Class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.

Competencies

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363-0585-00L Intermediate Econometrics W+ 3 credits 2V S. Stefanova

Abstract
The aim of the course is to discuss different econometric models and their empirical applications. We will cover cross-sectional linear and non-linear regression models, models for estimating treatment effects, and linear panel data models.

Objective
By the end of the course, students should understand the different existing approaches, their applicability, and their advantages and disadvantages. They should be able to read and understand regression output tables. Additionally, students will be able to apply the estimation approaches in practice using STATA.

Literature
Literature list provided on Moodle when the course starts.

https://moodle-app2.let.ethz.ch/course/view.php?id=20544
The lectures will consist of both theoretical and practical components. In the theoretical part, we will discuss each estimation approach in
detail. The lecture will present the assumptions, derivations, as well as the advantages and disadvantages of the estimation approach.

In the empirical part, we will look at simulation results using artificial data. Furthermore, we will investigate a particular research question
using STATA.

The course will tentatively cover the following subjects:
- review of ordinary least squares (OLS) estimation
- instrumental variable estimation and two-stage least squares estimation
- seemingly unrelated regression models
- simultaneous equation models
- maximum likelihood estimation
- binary response models
- count data models
- censored and truncated regression models
- sample selection models
- treatment effect models
- static linear panel data models (random effects and fixed effects estimation)

Lecture notes
For the theoretical portions of the lectures, we will prepare slides for in-class discussion. The format of the course is in-person. Slides will
be distributed electronically before each lecture.

For the applied portion of the lectures, we will provide STATA do files, log files, and data sets.

Problem sets will also be made available after every lecture. These problem sets will not be collected or graded, but students can use them
in order to prepare for the final exam. Solutions will be made available in the following lecture.

While there is no required textbook for the course, we draw from the following texts, which are also recommend for the preparation of the
exam:

Literature
Jeffrey M. Wooldridge: Introductory Econometrics; Jeffrey M. Wooldridge: Econometric Analysis of Cross Section and Panel Data; A. Colin
Cameron and Pravin K. Trivedi. Microeconometrics: Methods and Applications. Joshua A. Angrist and Jörn-Steffen Pischke: Mostly
Harmless Econometrics.

Prerequisites /
notice
Prior basic knowledge of matrix algebra and probability theory is strongly recommended.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Critical Thinking fostered
Integrity and Work Ethics fostered

Risk Analysis and Risk Management in Agriculture
W+ 3 credits 2G R. Finger

Abstract
Agricultural production is exposed to various risks and risk management is indispensable. This course introduces modern concepts on
farmers’ decision making under risk and risk management. We present innovative insights, empirical example from European agriculture.
You gain hands-on experience using R.

Objective
- to develop a better understanding of decision making under uncertainty and risk;
- to gain hands-on experience in risk analysis and management using R
- to gain experience in different approaches to analyze risky decisions;
- to develop an understanding for different sources of risk in agricultural production;
- to understand the crucial role of subjective perceptions and preferences for risk management decisions;
- to get an overview on risk management in the agricultural sector, with a particular focus on insurance solutions

Content
- Quantification and measurement of risk
- Risk preferences, Expected Utility Theory, Cumulative Prospect Theory
- Production and input use decisions under risk
- Portfolio Theory and Farm Diversification
- Forwards, Futures, Crop Insurance
- Weather Index Insurance and Satellite Imagery
- Empirical Applications using R

Lecture notes
Handouts will be distributed in the lecture and available on the moodle.

Prerequisites /
notice
knowledge of basic concepts of probability theory and microeconomics
What causes economic business cycles? How are limited resources, competition, and cooperation reflected in growth dynamics? To answer such questions, we combine macroeconomic models and methods of nonlinear dynamics. We study the role of bifurcations and control parameters for dynamic stability. Feedback cycles and coupled dynamics are reasons for limited predictability, instability and chaos.

Successful participants of the course are able to:
- formalize and solve one- and two-dimensional nonlinear models
- apply formal concepts to model economic growth and competition
- identify critical conditions for stability and dynamic transitions
- analyze macroeconomic models of business cycles, supply and demand
- apply formal concepts to model economic growth and competition

Weekly self-study tasks are used to apply the concepts introduced in the lectures. We practice how to solve nonlinear models formally and numerically and how to interpret the results.

Prerequisites / notice
Students should be familiar with nonlinear differential equations and should have basic programming skills. All necessary details to solve nonlinear models will be provided in the course. The course will not build on mathematical proofs, optimization, statistics, efficient numerical computation and other specialized skills.

Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

Methods-specific Competencies
- Communication fostered
- Operation and Teamwork fostered
- Sensitivity to Diversity fostered
- Adaptability and Flexibility fostered
- Critical Thinking analyzed
- Integrity and Work Ethics analyzed
- Self-awareness and Self-reflection analyzed
- Self-direction and Self-management analyzed

Social Competencies
- Communication fostered
- Operation and Teamwork fostered
- Sensitivity to Diversity fostered
- Adaptability and Flexibility fostered
- Critical Thinking analyzed
- Integrity and Work Ethics analyzed
- Self-awareness and Self-reflection analyzed
- Self-direction and Self-management analyzed

Personal Competencies
- Communication fostered
- Operation and Teamwork fostered
- Sensitivity to Diversity fostered
- Adaptability and Flexibility fostered
- Critical Thinking analyzed
- Integrity and Work Ethics analyzed
- Self-awareness and Self-reflection analyzed
- Self-direction and Self-management analyzed

401-0647-00L Introduction to Mathematical Optimization W 5 credits 2V+1U D. Adjiaashvili

Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering. The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Objective
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Literature

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies fostered

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:

2) individual decision making under risk
3) models of insurance demand, risk sharing, insurance supply
4) information issues in insurance markets
5) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Literature
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1;

Further readings:

References will be given on a topic-by-topic basis during the course.
Competencies | Subject-specific Competencies | Concepts and Theories | assessed
--- | --- | --- | ---
 | Method-specific Competencies | Analytical Competencies | assessed
 | Personal Competencies | Critical Thinking | assessed
 | | Self-direction and Self-management | fostered

### 363-1137-00L

**Applied Econometrics in Environmental and Energy Economics**

*Does not take place this semester.*

It is highly recommended to take 363-0570-00L Principles of Econometrics first.

#### Abstract

The course introduces the most common empirical methods for the analysis of issues in environmental, energy, and resource economics. The course includes computer laboratory sessions, and covers the following broad topics: demand models, discrete choice models, empirical methods in policy evaluation, field- and quasi-experiments.

#### Objective

At the end of the course, the students will be able to: understand the most common empirical methodologies used in environmental, energy, and resource economics; understand the problems the methodologies learnt in class aim to address; appreciate the importance of causal inference in empirical economics; read and understand the research papers in the literature; apply the empirical methods learnt in class using the software R.

#### Content

The course introduces students to empirical statistical methods that have wide application in environmental, energy, and resource economics and it is divided in four blocks. The first block is a quick review of the basic econometric methodology and concepts (OLS, standard errors, logit/probit models); the second block introduces demand models like the Almost Ideal Demand System, discrete choice models, and their evolutions; the third block explores causal inference in empirical economics and the main reduced-form econometric techniques used in policy evaluation, such as difference-in-differences, regression discontinuity and synthetic control; the fourth block introduces field experiments and instrumental variables, and their characteristics.

At the end of each block there will be a computer laboratory class in which the student will learn to apply the methodologies learnt in class using the statistical open-source software R. Throughout the course, students will have the chance to work on actual data used for analysis in economics papers.

The lectures will make use of current research papers in the literature to illustrate practical examples in which the methodologies learnt in class have been used. Students will be expected to read in advance the paper that will be explained during the lecture. The evaluation policy has the aim to allow students to get practical experience on the econometric methodologies learnt in class. Thus, beyond a final open-book computer exercise exam (60% of the grade), the course includes short takehome computer exercises (40% of the grade).

As the course will be centered on econometric methods, it is recommended that students have taken 363-0570-00L Principles of Econometrics first, or have otherwise a solid knowledge of basic econometric methodologies as detailed in Part 1 of Wooldridge, Jeffrey M. (2018) Introductory Econometrics : A Modern Approach. Seventh ed. ISBN: 978-1-337-55886-0. Knowledge of statistical software R is helpful, but not required and will be taught in the computer laboratory sessions.

#### Prerequisites / notice

It is highly recommended to take 363-0570-00L Principles of Econometrics first.

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### Project Management and Communication of Science

#### Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
751-5201-10L | Tropical Cropping Systems, Soils and Livelihoods (with Excursion) | W+ | 5 credits | 10G | J. Six, K. Benabderrazik

**IMPORTANT:** Students who enroll for this course are strongly recommended to verify with lecturers from other courses whether their absence of two weeks may affect their performance in the respective courses.

#### Abstract

This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in the Mount Kenya Region, which is co-organized with the University of Embu (Kenya).

#### Objective

1. Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
2. Interdisciplinary analysis of agricultural production systems
3. Knowledge on methods to assess agroecological performance of a tropical agroecosystems
4. Hands-on training on the use of field methods, diagnostic tools and survey methods.
5. Gain practical knowledge on how to assess to climate resilience and farming systems.
6. Collaboration in international students and stakeholders

#### Content

This course guides students in analyzing and comprehending tropical agroecosystems. Students of ETH Zürich will work together with the students from Embu University (Kenya) in an interdisciplinary and intercultural team. Students will focus on the Agroecological performance and climate resilience of diverse farming systems in the Mount Kenya Region.

From October 28th to November 11th, The students will take part in a field course in the Mount Kenya Region. Students will then gain practical knowledge on field, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

#### Prerequisites / notice

We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 18rd 2023, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.
### Professional Internship

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<tr>
<th>Number</th>
<th>Title</th>
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<td>751-0210-00L</td>
<td>Professional Internship</td>
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**Abstract**

Students primarily work on a defined task or internship project in a professional environment within the field of Agricultural Sciences. By doing so, they apply the subject-specific, method-specific, social, and personal competencies acquired during their studies in their daily work and further develop and deepen them. Additionally, they reflect upon and present their internship experiences.

**Objective**

The students will set their own learning and working goals, and reflect on learning and work performance within the framework of their internship provider.

**Content**

- a preparatory phase, which includes an information event, the attendance of Agro Day II as well as seeking a suitable internship position.
- the placement period, preferably in the 3rd semester of the master's programme, but necessarily before the master's thesis, lasting at least 16 weeks. During placement period, additional written assignments will be completed.
- a follow-up phase, which includes presenting a "1-minute presentation" and discussing a poster on Agro-Day II.

**Prerequisites / notice**

Der Praktikumsaufenthalt wird in der Regel im dritten Master-Semester, in jedem Fall vor Beginn der Master-Arbeit absolviert. Er kann erst absolviert werden, wenn

- die Bachelor-Arbeit im Studiensekretariat abgegeben wurde;
- eine Einschreibung ins Master-Studium Agrarwissenschaften erfolgt ist;
- allfällige Zulassungsauflagen erfüllt sind.

Falls in einem Semester nur die Lehrveranstaltung Berufspraktikum belegt wird, kann man sich in ein Urlaub einschreiben. Genaue Informationen finden sich im Moodle Kurs.

### Minors

#### Agricultural Economics and Policy

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<tr>
<th>Number</th>
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<tr>
<td>751-2903-00L</td>
<td>Evaluation of Agricultural Policies</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>R. Huber, R. Finger, C. Schader</td>
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</table>

**Abstract**

In this course, students get an overview of agricultural policy evaluations and their societal and political relevance. They learn to understand and apply the principles of scientific based evaluations of agricultural policies.

**Objective**

The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) They know the basics of how to design and implement a policy evaluation study. 3) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.). They make hands-on experiences of methodological challenges. 4) They can critically assess the science-policy interface of policy evaluations.

**Content**

The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.
**Management for Enterprises in the Agri-Food-Chain II**

**Abstract**
Advanced Management in the Agri-Food Chain:
Framework and models for management of organizations in the Agri-Food Chain in a complex environment.

**Objective**
- Students learn the basic theory and practice of dynamic simulation.
- Know the characteristics and consequences of complexity in the organizational world.
- Know possible practical applications and examples of the treated contents to organizations in the Agri-Food Chain and are able to deepen the relevant topics in an autonomous way.

**Content**
In the lecture the following contents will be treated:
- State, reasons and effects of complexity in the organizational world.
- A basic framework for shaping and governing intelligent organizations.
- Selected contemporary models for managing in the complex organizational world.
- Transfer and adaption of the models to organizations in the Agri-Food Chain.

**Lecture notes**
Reader with selected contents.

**Prerequisites / notice**
- Vorlesung "Management für Unternehmen der Agrar- & Ernährungswirtschaft I" in D-USYS

**Competencies**

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<tr>
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<td>Subject-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<td>Cooperation and Teamwork</td>
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<td>Critical Thinking</td>
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**Socioeconomics of Agriculture**

**Abstract**
The main part of this lecture will examine constellations where hierarchies, markets or cooperation have been observed and described in the agricultural sector. On a more aggregated level, different agricultural systems will be evaluated in terms of main socioeconomic parameters like social capital or perceptions.

**Objective**
Students should be able to describe the dynamics of hierarchies, markets and cooperation in an agricultural context.

**Content**
Introduction to Sociology
Introduction to Socioeconomics
Agricultural Administration: Path dependencies and efficiency issues
Power in the Chain
The farming family
Occupational Choices
Market segregation
The issue of meat demand
Common Resource Management in Alpine Farming
Agricultural Cooperatives
Societal perceptions of agriculture
Perceptions of farming from within
Varieties of agricultural systems and policies

**Lecture notes**

**Prerequisites / notice**
Basic economic knowledge is expected.

**Competencies**

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**Dynamic Simulation in Agricultural and Regional Economics**

**Abstract**
In this class, students learn the basics of system dynamics and its application to agricultural and regional economic questions. In the second half of the class, students develop their own simulation model, with which they evaluate potential interventions for improving the economic as well as the ecological sustainability of food systems.

**Objective**
- Students learn the basic theory and practice of dynamic simulation.
- Students can develop, analyze and extend a dynamic simulation model and interpret its results.
- By applying the developed simulation model, students gain insights into food system issues. They also learn to recognize the benefits and pitfalls of dynamic simulation, both from a theoretical and an applied perspective.

**Lecture notes**
Slides (will be provided during the class); articles and papers (will be provided during the class).

**Risk Analysis and Risk Management in Agriculture**

**Abstract**
Agricultural production is exposed to various risks and risk management is indispensable. This course introduces modern concepts on farmers' decision making under risk and risk management. We present innovative insights, empirical example from European agriculture.

**Objective**
- to develop a better understanding of decision making under uncertainty and risk;
- to gain hands-on experience in risk analysis and management using R;
- to develop an understanding for different sources of risk in agricultural production;
- to understand the crucial role of subjective perceptions and preferences for risk management decisions;
- to get an overview on risk management in the agricultural sector; with a particular focus on insurance solutions.
**Content**
- Quantification and measurement of risk
- Risk preferences, Expected Utility Theory, Cumulative Prospect Theory
- Production and input use decisions under risk
- Portfolio Theory and Farm Diversification
- Forwards, Futures, Crop Insurance
- Weather Index Insurance and Satellite Imagery
- Empirical Applications using R

**Lecture notes**
Handouts will be distributed in the lecture and available on the moodle.

**Prerequisites / notice**
Knowledge of basic concepts of probability theory and microeconomics

**Competencies**

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<td>Media and Digital Technologies</td>
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**Literature**
Literature and readings will be announced. For a basic understanding we recommend the Handbook of Good Research by Jürgen Brock and Florian von Wangenheim.

**Prerequisites / notice**
The course includes out-of-class assignments to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Assignments will be graded and need to be turned-in on time as they will be shown and discussed in class. Class participation is encouraged and can greatly improve students' learning. In this spirit, students are expected to attend class regularly and come to class prepared.

**Competencies**

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**363-0305-00L**
Empirical Methods in Management

**Abstract**
In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evidence-based decision-making. The class includes assignments related to the lecture content.

**Objective**
The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

**Content**
Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understanding of statistical approaches. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature. Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics.

The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to that, there will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.

**Literature**
Articles and book abstracts will be uploaded to a course website.

**851-0626-01L**
International Development Cooperation

**Abstract**
The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.

**Objective**
Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid. Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.

**Content**
Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid: e.g. Micro-Finance, Budget-Support; Fair-Trade.

**Literature**
Books and articles will be uploaded to a course website.

**Animal Sciences**

**Number**

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-6001-00L</td>
<td>Forum: Livestock in the World Food System</td>
<td>W+</td>
<td>2 credits</td>
<td>2S</td>
<td>S. Meese</td>
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**Abstract**
This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.

**Objective**
In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society).

The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.
The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

**Part 1**
Aspect 1 - Oral presentation: The students form small groups and are lecturers.
Aspect 2 - chairperson: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

**Part 2.**
Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Introductions to both presentation forms will be given by the lecturer.

**Lecture notes**
**Prerequisites / notice**
- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)
- feedback on the presentation style of a student

**Competencies**

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<td>Self-direction and Self-management</td>
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**751-6501-00L Ruminant Science**

**W+** 4 credits 4G M. Niu, M. Terranova, U. Witschi

**Abstract**
The course provides the scientific basis of the central aspects of reproduction and nutrition physiology of ruminants, and of the implications for animal health, product quality, and breeding programs. Means of knowledge transfer include interdisciplinary approaches, disciplinary parts, web-based learning and self-study.

**Objective**
At the end of the course the students are able to apply, by a comprehensive understanding of the underlying mechanisms, their knowledge in various fields of ruminant science. They will be able to develop and recommend best strategies for breeding programs, feed formulation, improving forage quality, and increasing animal health. They will be trained to carry out interdisciplinary and disciplinary research at the highest level.

**Content**
- Fields (contact hours)
  - Introduction: 2 h
  - Special topics: 20 h
  - Rumen Anatomy
  - Hohenheim Gas Test
  - Calf health
  - Reproduction Techniques
  - Fertility in Cows
  - Disciplinary topics: 32 h
  - Ruminal Digestion: 8 h
  - Ruminant Nutrition Physiology: 12 h
  - Reproduction in Ruminants: 8 h
  - Lectures held by the students: 4 h

In summary
- Contact hours: 58 h
- Self-study within semester: 30 h (especially preparation for the interdisciplinary courses and the own lecture)
- Self-study in semester break: 32 h
Total: 120 h

**Lecture notes**
**Literature**
**Prerequisites / notice**
The specialty of this course is that for the first time the animal science disciplines are unified. This is realised with a particular emphasis on interdisciplinary special topics and new forms of teaching. At the same time the essential basics in the central fields are communicated.

Conditions for successful participation: Background on animal science from the Bachelor is desired. In order to attend the Minor in Ruminant Science without any animal science background, a realistic self-assessment concerning the need for additional self-study is recommended (e.g. by choosing an appropriate bachelor course which then may be counted as 'optional courses' in the master). These efforts depend on the extent to which animal science courses have already been attended in the bachelor.

The control of performance will consist of:
- an own short lecture
- a final oral examination with focus on comprehension of the fundamental linkages rather than of specific details

**751-6243-00L Breeding and Conservation of Animal Genetic Resources**

**W+** 2 credits 2V H. Signer-Hasler, C. Flury

**Abstract**
Animal genetic resources refer to the genetic and species diversity of livestock. Only a few production breeds have been further developed through breeding, while local breeds have no longer been able to survive in this competition. Without the support of endangered breeds and the sustainable breeding of productive breeds, many regionally typical breeds are threatened with extinction.
**Objective**

Learning Objectives: Part 1:
At the end of the course, students are able to assess the importance and problems of small ruminant breeding and husbandry in Switzerland and neighbouring countries. They know the most important breeding objectives and are able to assess them in terms of production and sustainable development in small ruminants and cattle.

Learning objectives part 2:
The second part gives an overview of the distribution, endangerment and conservation of breed diversity of farm animals in Switzerland and internationally. The theory is illustrated with numerous examples and the knowledge is deepened in exercises.

The students:
- have an overview of the national and international distribution of animal genetic resources and are familiar with the database DAD-IS (Domestic Animal Diversity Information System).
- can name the national and international efforts to conserve agricultural livestock breeds.
- know how to describe genetic diversity.
- can point out what is important in the management of small populations.
- can describe different conservation measures, especially in situ and ex situ conservation.
- can describe current national and international conservation programmes for different livestock breeds.

**Prerequisites / notice**

Examination:
Examination Part 1: Graded written examination (1 hour) on the material covered. Examination Part 2: Graded semester performance completed during the block course. Parts 1 and 2 contribute equally to the final grade.

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**Crop- and Grassland Science**

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<th>Number</th>
<th>Title</th>
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<td>751-4104-00L</td>
<td>Alternative Crops</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. Walter, K. Berger Büter</td>
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**Abstract**
Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

**Objective**
During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories: fostered
- Method-specific Competencies
  - Media and Digital Technologies: fostered
  - Problem-solving: fostered
  - Project Management: fostered
  - Cooperation and Teamwork: assessed
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: fostered
- Social Competencies
  - Communication: assessed
- Personal Competencies
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: fostered

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<tr>
<td>751-3603-00L</td>
<td>Current Challenges in Plant Breeding</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>B. Studer, A. Hund, R. Kölliker</td>
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**Abstract**
The seminar 'Current Challenges in Plant Breeding' aims to bring together national and international experts in plant breeding to discuss current activities, latest achievements and future prospective of a selected topic/area in plant breeding.

**Objective**
The educational objectives cover thematic, methodic as well as social and personal competencies:
- Deepening of scientific knowledge in plant breeding
- Critical evaluation of current challenges and new concepts in plant breeding
- Promotion of collaboration and Master thesis projects with practical plant breeders
- Independent literature research to get familiar with the selected topic
- Critical evaluation and consolidation of the acquired knowledge in an interdisciplinary team
- Establishment of a scientific presentation in an interdisciplinary team
- Presentation and discussion of the teamwork outcome
- Establishing contacts and strengthening the network to national and international plant breeders and scientist

**Content**
Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).

**Lecture notes**
None

**Literature**
Peer-reviewed research articles, selected according to the topic.

**Prerequisites / notice**
Participation in the BSc course ‘Pflanzenzüchtung’ is strongly recommended, a completed course in ‘Molecular Plant Breeding’ is advantageous.
The course focuses on alien organisms in agriculture as well as the scientific assessment and regulatory management of their effects on the environment and agricultural production. Alien organisms in agriculture is a topic that receives an increasing awareness among farmers, agricultural scientists, regulators and the general public. Students of this course will learn about the nature of alien organisms such as invasive species, biocontrol organisms and genetically modified organisms. With a particular focus on arthropods, plants and their interactions we will look at the potential threats the novel organisms pose, the benefits they provide and how both of these effects can be scientifically assessed. Students will learn how the topic of alien organisms in agriculture is intrinsically tied to policy making and regulation and get to know current examples and future challenges in research. In the last part of the course students will be able to apply the acquired knowledge in a practical exercise (case study).

Material will be distributed during the course. A part of the course will take place in flipped classroom mode, i.e. some lectures will be available as podcasts.

This course focuses on the interactions between ecology, biogeochemistry and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems. Students will analyse and understand the complex and interacting processes of ecology, biogeochemistry and management of agroecosystems. They will use their theoretical knowledge in two flipped classroom exercises, but also set up a small weather station and different meteorological and greenhouse gas flux data will be analysed (using R) and assessed in terms of production, greenhouse gas budgets, and carbon sequestration. Thus, students will learn how to collect, analyse and interpret data about the complex interactions of a coupled human-environmental system.

Students will work in groups (3-4 persons per group) with data from a small weather station (dedicated to the course), as well as data from the long-term measurement network Swiss FluxNet and from global databases. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

Handouts will be available in moodle.

Prerequisites: Attendance of introductory courses in plant ecophysiology, ecology, and grassland or forest sciences. Knowledge of data analyses in R and statistics. Course will be taught in English.
Current Aspects of Nutrient Cycle in Agro-Ecosystems

Abstract
The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is "Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments".

Objective
Analyze publications and/or data records on long-term field experiments regarding their content on integrated nutrient management and derive the nutrient use efficiency; link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.

Content
The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is "Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments". The students will analyze and connect the results published (or from data records) for selected field experiments in a group work. They will present their analysis in a report and in an oral presentation. The seminar is composed by presentations of experts and of the students. The presentations will be synthesized during a final discussion.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Project Management

- Social Competencies
  - Cooperation and Teamwork

- Personal Competencies
  - Critical Thinking
  - Self-direction and Self-management

751-4003-01L Current Topics in Grassland Sciences (autumn)

Abstract
Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as by doctoral and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

Objective
Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.

Content
Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as by doctoral and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

Lecture notes
none

Prerequisites
Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.

751-4506-00L Plant Pathology III

Abstract
Identification based on host, symptoms and micro-morphology, completed with life cycles and related control measures of the most important fungal diseases and their causal pathogens of annual and perennial crops with agricultural significance.

Objective
The students will learn and train preparation skills for microscopy, acquire knowledge of selected diseases (identification, biology of pathogen, epidemiology and systematics) and understand the corresponding integrated control measures practiced in Swiss agriculture.

Content
A script will be used on annual and perennial crops and their most important diseases. It will be updated stepwise.

Lecture notes

Prerequisites
The course will be in German (spec. nomenclature)
Environmental Systems Data Science: Data

B. Streit

The course provides the first part of an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for environmental scientists. R is free software with a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

### Prerequisites

- Mathematical knowledge up to University level
- Basic knowledge of programming
- Basic Excel knowledge

### Content

- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

### Objective

The students are able to

- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

### Lectures

- L. Pellissier, C. P. Albouy, M. Volpi
- M. Mächler

### Competencies

- Personal Competencies: Critical Thinking
- Method-specific Competencies: Analytical Competencies, Problem-solving
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies

### Data Science and Technology for Agricultural Science

#### 751-4704-00L Weed Science

**Abstract**

Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops.

**Objective**

At the end of the course the students are qualified to develop sustainable solutions for weed problems in agricultural and natural habitats.

**Content**

Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops. Accordingly, this knowledge will be imparted during the course and will be required to understand the mechanisms of integrated weed control strategies.

#### Using R for Data Analysis and Graphics (Part I)

**Number** 701-3001-00L

**Title** Environmental Systems Data Science: Data Processing

**Type** W

**ECTS** 2

**Hours** 2G

**Lecturers** L. Pellissier, C. P. Albouy, M. Volpi

**Abstract**

Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

**Objective**

The students are able to

- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

**Content**

- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

**Prerequisites / notice**

- 252-0840-02L Anwendungsnahe Programmieren mit Python
- 401-0624-00L Mathematik IV: Statistik
- 401-6215-00L Using R for Data Analysis and Graphics (Part I)
- 401-6217-00L Using R for Data Analysis and Graphics (Part II)
- 701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt- und Naturwissenschaften

#### Using R for Data Analysis and Graphics (Part II)

**Number** 401-6215-00L

**Title** Using R for Data Analysis and Graphics (Part I)

**Type** W

**ECTS** 1.5

**Hours** 1G

**Lecturers** A. Hauser

**Abstract**

The course provides the first part of an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

**Objective**

The students will be able to use the software R for simple data analysis and graphics.

**Content**

The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:

- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www rstudio.org

**Lecture notes**

An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

**Prerequisites / notice**

The course resources will be provided via the Moodle web learning platform. Subscribing via Mystudies "automatically" makes you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=20847

**Competencies**

- Personal Competencies: Critical Thinking
- Method-specific Competencies: Analytical Competencies, Problem-solving
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies

#### 401-6217-00L Using R for Data Analysis and Graphics (Part II)

**Number** 401-6217-00L

**Title** Using R for Data Analysis and Graphics (Part II)

**Type** W

**ECTS** 1.5

**Hours** 1G

**Lecturers** M. Mächler

**Abstract**

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www rstudio.org

**Lecture notes**

An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

**Prerequisites / notice**

The course resources will be provided via the Moodle web learning platform. Subscribing via Mystudies "automatically" makes you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=20847

**Competencies**

- Personal Competencies: Critical Thinking
- Method-specific Competencies: Analytical Competencies, Problem-solving
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies

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The course provides the second part of an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

Note: This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

Abstract

The students will be able to use the software R efficiently for data analysis, graphics and simple programming.

Objective

The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Content

Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tailoring R: options;
- Extending basic R: packages

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

Prerequisites / notice

Basic knowledge of R equivalent to "Using R... (part I)" (= 401-6215-00L ) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=20848

Competencies

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751-5510-00L Introduction to Agricultural Robotics W+ 3 credits 2G S. Mintchev

Abstract

Autonomous robots are quickly becoming a key player in the transition to precision agriculture. In this course, students will learn theoretical and practical aspects of robotics. Lectures will introduce how robots operate and analyse their application to precision agriculture. In hands-on laboratories, students will apply concepts learned in class on educational robots to simulate a weeding task.

Objective

After the course, students will be able to critically examine and select appropriate robotic solutions for agricultural applications.

The learning objectives of the course are: (i) illustrate the principle of operation of the main components of a robotic system, (ii) analyse how the different robotic components are integrated and contribute to the functioning of a robotic system, and (iii) solve problems in the field of agriculture using robotic principles.

Content

Robots are becoming a key technology in the transition to smart farming and in supporting the agricultural needs of the 21st century. For example, robots enable site-specific fertilization, automated weeding, or livestock herding.

The course gives an overview of robotic systems, beginning with their fundamental components (e.g., sensors, actuators, locomotion strategies) and gradually scaling up to the system level, illustrating the concepts of perception, robot control, obstacle avoidance and navigation. Exercises performed with an educational robot (Thymio) will complement the theoretical lectures providing a hands-on practical experience of the challenges of using these machines.

During the course, students will gradually apply the theoretical and practical knowledge they are learning. To this end, students will work in teams to develop a robotic solution for an agricultural task of their choice. Students will learn to translate the task into meaningful requirements for a robotic system and critically select the most appropriate components to achieve the required robotic functions. Students will periodically present and discuss the development of this "robot design" exercise during presentations and in a journal report.

Lecture notes

Copies of the slides and exercises will be provided on the course Moodle page.

Literature


Prerequisites / notice

No mandatory prerequisites, but it is preferable that students have a basic knowledge of computer programming.

Class size limitation to 30 students.
701-0951-00L GIST - Introduction into Geoinformation Science and Technology  

Abstract: Theoretical basics and fundamental concepts of Geographic Information Science are imparted and subsequently further elaborated with the software ArcGIS.

Objective: Students are able to:
- elucidate the theoretical and conceptional foundations of geographic information systems (GIS)
- independently perform normal GIS work using commercial software and practical examples

Content:
- What is GIS? What are spatial data?
- The representation of reality by means of spatial data models: vector, raster, TIN
- The four phases of data modelling: Spatial, conceptual, logical and physical model
- Possibilities of data collection
- Transition of reference frame
- Spatial Analysis I: query and manipulation of vector data
- Spatial Analysis II: operators and functions with raster data
- Digital elevation models and derived products
- Process modelling with vector and raster data
- Presentation possibilities of spatial data

One Friday is reserved for a field trip or guest speaker;

Literature:

Prerequisites / notice: Aufgrund der Grösse des verfügbaren EDV-Schulungsraumes ist die Teilnehmerzahl auf 50 Studierende beschränkt! Für die Übungen werden die Studierenden auf zwei, max. drei Zeitfenster aufgeteilt. Pro Zeitfenster können maximal 25 Studierende betreut werden.

651-4031-00L Geographic Information Systems  

Abstract: Introduction to the fundamental concepts and data processing capabilities of Geographic Information Systems (GIS). Practical application of geospatial data management and analysis functions based on a selected geoscience project.

Objective: Students can:
- explain the basic principles of GIS
- solve a complex, real-world GIS problem in the field of Earth Science
- apply the principles of data modelling and geoprocessing with ArcGIS Pro: data design and modelling, data acquisition, data integration of different data types (including LiDAR data), spatial analysis of vector and raster data, special functions for digital terrain modelling and hydrology, map production and 3D visualisation.

Content: Theoretical introduction to the concepts, spatial data types and spatial data handling functions of Geographic Information Systems (GIS). Application of data modeling principles and geoprocessing capabilities using ArcGIS Pro: data design and modeling, data acquisition, data acquisition and integration, spatial analysis of vector and raster data, particular functions for digital terrain modeling and hydrology, map generation and 3D-visualization.

Lecture notes: Lecture Script: Introduction to Geographic Information Systems, Tutorial: Introduction to ArcGIS Pro. All lecture materials are provided digitally.

Literature:
Building on existing data science resources

The CNNAP course discusses the mechanistic relationships between nutrient speciation in fertilizer and nutrient uptake by plants using concepts and theories. Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods.

Environmental Systems Data Science: Machine Learning

The students are able to:
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

The data science workflow:
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The students are able to:
- analyze publications and/or data records on long-term field experiments regarding their content on integrated nutrient management and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- derive the nutrient use efficiency; link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- link the information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.

Environmental Systems Data Science: Machine Learning

The students are able to:
- access online resources to keep up with the latest data science methodology and deepen their understanding
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- build and validate regressions and neural network models
- get to know machine learning approaches including regression, random forest and neural network
- model complexity and hyperparameters
- model parameterization and loss
- model evaluations and uncertainty
- deep learning with convolutions

Current Aspects of Nutrient Cycle in Agro-Ecosystems

The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The students are able to:
- analyze publications and/or data records on long-term field experiments regarding their content on integrated nutrient management and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- derive the nutrient use efficiency; link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- link the information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
- link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.

Chemical Nature of Nutrients and their Availability to Plants: The Case of Phosphorus

The CNNAP course discusses the mechanistic relationships between nutrient speciation in fertilizer and nutrient uptake by plants using phosphorus as an example. The course involves theoretical aspects of nutrient cycling, laboratory work, data analysis and presentation, and the use of advanced methods in plant nutrition studies.
At the end of the CNNAP course, participants will obtain a mechanistic understanding of why and how the speciation of phosphorus in fertilizer can affect its release to the soil solution and subsequent uptake by plants. Students will be able to use this information for the development of fertilization schemes that maximize the nutrient uptake and fertilizer efficiency of crops or pastures. During the course, participants will become familiar with the use of radiotopes and nuclear magnetic resonance as approaches to measure nutrient availability and forms, respectively and they will know the limits of these techniques. Students will also have the opportunity to improve their laboratory, presentation, discussion and writing skills.

**Objective**

At the end of the CNNAP course, participants will:

- Obtain a mechanistic understanding of why and how phosphorus in fertilizer can affect its release to the soil solution and subsequent uptake by plants.
- Use information for the development of fertilization schemes that maximize nutrient uptake and fertilizer efficiency of crops or pastures.
- Become familiar with the use of radiotopes and nuclear magnetic resonance as approaches to measure nutrient availability and forms.
- Know the limits of these techniques.
- Improve their laboratory, presentation, discussion, and writing skills.

**Lecture notes**

Documents will be distributed during the lecture.

**Literature**

Documents will be distributed during the lecture.

**Prerequisites / notice**

The CNNAP lecture will take place at the ETH experimental station in Eschikon Lindau every second year. The next course will be organized in autumn 2024.

The CNNAP course will take place if and only if 8 or more students are registered one week before the start.

See the location of the station at: http://www.plantnutrition.ethz.ch/the-group/how-to-find-us.html

We strongly advise students who are planning to be absent for more than one week during the semester NOT to visit this course.

Students should have visited the plant nutrition lectures in the 3rd and 6th semesters and the lecture pedosphere in the 3rd semester of the agricultural study program of the ETH. If students do not have visited these courses they will have to acquire the necessary information by themselves as this knowledge is indispensable for the CNNAP course.

As the CNNAP course does not take place in autumn 2023, we recommend students interested in integrated assessment of nutrient cycling in soil plant systems to visit the 8th semester lecture 751-3404-00L (Nutrient Fluxes in Soil-Plant Systems: The Case of Nitrogen) organized in spring 2024 by Oberson et al.

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**

- Communication: assessed

**Personal Competencies**

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**Abstract**

This course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions.

**Objective**

Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small IsoProject, practice to search and analyze literature as well as to give an oral presentation.

**Content**

The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

**Lecture notes**

Handouts will be available on the webpage of the course.

**Literature**

Will be discussed in class.

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**

- Communication: assessed

**Personal Competencies**

- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**Abstract**

This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples.

**Objective**

1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants.
2. Quantitative applications of chemical equilibria to processes in natural systems.

The course "Soil and Water Chemistry" teaches, applies and examines the competences process understanding, systems understanding, and modelling.

**Content**

Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.

**Lecture notes**

Lecture slides on Moodle

**Literature**

- Chapters 1, 3, 4, 6, 7 and 11 in Sigg/Stumm – Aquatische Chemie, 6. Auflage, vdf, 2016.
Prerequisites / notice
The lecture courses Pedosphere and Hydrosphere are highly recommended.

Competencies

Subject-specific Competencies
Concepts and Theories
assessed
Techniques and Technologies
assessed

Method-specific Competencies
Analytical Competencies
assessed
Problem-solving
assessed

Social Competencies
Communication
fostered

Personal Competencies
Critical Thinking
fostered

Environmental Soil Physics/Vadose Zone Hydrology
W 3 credits 2V+1U A. Carminati, P. U. Lehmann Grunder

Abstract
The course provides theoretical and practical foundations for understanding and characterizing physical soil properties and processes and their relevance for terrestrial ecosystems, plant growth, hydrological processes and atmospheric-land gas exchange, across all relevant scales.

Objective
Students are able to:
- Characterize the different soils based on their key textural and structural properties.
- Simulate and predict soil water retention and flow under varying environmental conditions and understand the key driving forces (capillarity, gravity, friction) and related water properties (surface tension and viscosity).
- Predict soil hydraulic properties for varying soil textural classes.
- Predict solute transport in soils for varying environmental conditions.
- Predict energy balance and temperature dynamics in soils.
- Predict conditions for plant water stress
- Estimate the impact of soil properties on the hydrological cycle and on plant growth.

Content

INTRODUCTION
Week 1 (September 18)
Presentation of the role of soil physics in environmental sciences and terrestrial ecosystems: soils in the water cycle; soils and vegetation; soils and solute transport. Survey on students' interests and expectations. Presentation of course structure and learning objectives.

BASIC SOIL PROPERTIES
Week 2 (September 25) and Week 3 (October 02)
soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density
Pore scale consideration (water in a single pore), pore sizes and shapes; surface tension; Young-Laplace equation; capillary rise; contact angle
Friction and laminar flow; Hagen-Poiseuille's law; Washburn equation; numerical lab (REPORT 1)

SOIL HYDRAULIC PROPERTIES
Week 4 (October 09) and Week 5 (October 16)
Soil water potential and soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point
Soil water characteristics and pore size distribution
Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts; effective conductivity; unsaturated hydraulic conductivity; Buckingham law.
Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications

TOOLBOX – MEASUREMENTS AND MODELING
Week 6 (October 23) and Week 7 (October 30)
Measuring soil hydraulic properties, fitting and interpretation; Lab tour - demonstration of soil physical methods; lecture on HYPROP method; report on HYPROP data (REPORT 2)
Modelling unsaturated water flow based on Richards equation - Using Hydrus1D for simulation of unsaturated flow; simulating HYPROP measurements (REPORT 3)

SOIL IN THE WATER CYCLE
Week 8 (November 06) – Week 9 (November 13)
Water infiltration - steady state solutions for infiltration; approximate solutions to infiltration (Green-Ampt, Philip); infiltration rate and ponding; outlook to preferential flow
Water evaporation - Energy balance and land atmosphere interactions - potential and actual evaporation, evaporation stages;

SOIL PLANT INTERACTIONS
Week 10 (November 20) Week 11 (November 27)
Root water uptake and transpiration – Theory and mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance.
Modelling root water uptake and transpiration; analytical approaches and modeling using Hydrus (REPORT 4)

SOLUTE TRANSPORT
Week 12 (December 04) Week 13 (December 11)
Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application
Transport of reactive substances, preferential flow, simulations with Hydrus

CLOSURE
Week 14 (December 18)
Summary, course synthesis, connections between the different topics, questions, exam preparation

Literature
Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel
This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in the Mount Kenya Region, which is co-organized with the University of Embu (Kenya).

**Abstract**

This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in the Mount Kenya Region, which is co-organized with the University of Embu (Kenya).

**Objective**

(1) Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
(2) Interdisciplinary analysis of agricultural production systems
(3) Knowledge on methods to assess agroecological performance of a tropical agroecosystems
(4) Hands-on training on the use of field methods, diagnostic tools and survey methods.
(5) Gain practical knowledge on how to assess to climate resilience and farming systems.

**Content**

This course guides students in analyzing and comprehending tropical agroecosystems. Students of ETH Zürich will work together with the students from Embu University (Kenya) in an interdisciplinary and intercultural team. Students will focus on the Agroecological performance and climate resilience of diverse farming systems in the Mount Kenya Region.

From October 28th to November 11th, The students will take part in a field course in the Mount Kenya Region. Students will then gain practical knowledge on field, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.
Food and Consumer Behaviour

**Title:** Food and Consumer Behaviour  
**Type:** W  
**ECTS:** 2  
**Hours:** 2V  
**Lecturers:** M. Siegrist, F. Michel

**Abstract:** This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products. Students will be able to:

- to describe heuristics that influence consumer behavior in the food domain  
- to explain the consumer led food product development  
- to summarise how consumers perceive the environmental impact and the healthiness of foods  
- to assess the cultural, the environmental and the food policy impact on consumer behavior  
- to explain psychological factors influencing eating behavior

**Competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies  
- Method-specific Competencies: Analytical Competencies, Decision-making, Problem-solving  
- Social Competencies: Communication  
- Personal Competencies: Adaptability and Flexibility

**Lecture notes:** There is no script. Powerpoint presentations and relevant scientific articles will be available online for students. A selection of 20 students will be done on the basis of the letters.

**Prerequisites / notice:** The course is open to master and MAS students in food science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

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Nutritional Aspects of Food Composition and Processing

**Title:** Nutritional Aspects of Food Composition and Processing  
**Type:** W  
**ECTS:** 3  
**Hours:** 2V  
**Lecturers:** B. E. Baumer, J. M. Sych

**Abstract:** Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.

- describe and compare the major concepts /criteria used for the evaluation of the nutritional quality of food  
- apply these criteria when assessing the effects of selected processing technologies on nutritional quality.  
- evaluate recent formulation strategies aimed to achieve additional physiological benefits for targeted population groups (i.e. functional foods),

**Content:** The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, separation and emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.

**Lecture notes:** There is no script. Powerpoint presentations and relevant scientific articles will be available online for students. A selection of recommended readings will be given at the beginning of the course.

**Prerequisites / notice:** The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

**Competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies  
- Method-specific Competencies: Analytical Competencies, Decision-making  
- Social Competencies: Communication  
- Personal Competencies: Critical Thinking

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Bioactive Feed Compounds and Enriched Food Products

**Title:** Bioactive Feed Compounds and Enriched Food Products  
**Type:** W  
**ECTS:** 2  
**Hours:** 2V  
**Lecturers:** M. Niu, to be announced

**Abstract:** The course provides students with the basic knowledge to understand the connection between the structure of nutritive and non-nutritive bioactive food and feed components and their effects on the nutrient supply and health of humans and livestock as well as on the quality of animal-derived foods.

**Objective:** At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

**Content:** The course gives an introduction into different classes of bioactive components present in food and feed including fatty acids and secondary plant compounds such as carotenoids, polyphenols, phytoestrogens, glucosinolates, protease inhibitors and monoterpenes.

**Topics include:**

- sources of bioactive food and feed components  
- bioavailability and modification in the gastrointestinal tract  
- beneficial and detrimental effects  
- molecular mechanisms of biological effects  
- species differences concerning metabolism and biological effects
Alternative Crops

Abstract
Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

Objective
During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

Competencies

Subject-specific Competencies
- Concepts and Theories: fostered

Method-specific Competencies
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

Alternative Crops

W+ 2 credits 2V A. Walter, K. Berger Büter

Abstract
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Competencies

Subject-specific Competencies
- Concepts and Theories: fostered

Method-specific Competencies
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

Political Ecology of Food and Agriculture

Number of participants limited to 25
A motivational application is required:
- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Abstract
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

Objective
- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

Content
We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

Competencies

Subject-specific Competencies
- Concepts and Theories: fostered

Method-specific Competencies
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

Political Ecology of Food and Agriculture

W+ 3 credits 2G J. Jacobi

Number of participants limited to 25
A motivational application is required:
- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Abstract
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Competencies

Subject-specific Competencies
- Concepts and Theories: fostered

Method-specific Competencies
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

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W+ 3 credits 2G J. Jacobi

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The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid. Students will gain an overview on institutions and actors’ roles in the field of sustainable agricultural development. Throughout the group work, students will learn to engage directly with various stakeholders, monitor agroecological transition and communicate their research to a wider audience. Ultimate, this course should provide an overview on methods, tools, innovations and platforms that support a sustainable food transformation.

**Literature**


**Prerequisites / notice**

Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.
The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

**Part 1**

Aspect 1 - Oral presentation: The students form small groups and are lecturers.
Aspect 2 - chairperson: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

**Part 2**

Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Introductions to both presentation forms will be given by the lecturer.

**Lecture notes**

no scriptum

**Prerequisites / notice**

Requirements for allocation of the two credit points:

- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)
- feedback on the presentation style of a student

**Competencies**

**Subject-specific Competencies**

Concepts and Theories: assessed
Techniques and Technologies: fostered

**Method-specific Competencies**

Analytical Competencies: fostered
Decision-making: fostered
Problem-solving: fostered

**Social Competencies**

Cooperation and Teamwork: fostered
Sensitivity to Diversity: fostered

**Personal Competencies**

Adaptability and Flexibility: fostered
Creative Thinking: fostered
Critical Thinking: fostered
Self-awareness and Self-reflection: fostered
Self-direction and Self-management: fostered

**Content**

This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in the Mount Kenya Region, which is co-organized with the University of Embu (Kenya).

**Abstract**

This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in the Mount Kenya Region, which is co-organized with the University of Embu (Kenya).

**Objective**

(1) Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
(2) Interdisciplinary analysis of agricultural production systems
(3) Knowledge on methods to assess agroecological performance of a tropical agroecosystems
(4) Hands-on training on the use of field methods, diagnostic tools and survey methods.
(5) Gain practical knowledge on how to assess to climate resilience and farming systems.
(6) Collaboration in international students and stakeholders

**Content**

This course guides students in analyzing and comprehending tropical agroecosystems. Students of ETH Zürch will work together with the students from Embu University (Kenya) in an interdisciplinary and intercultural team. Students will focus on the Agroecological performance and climate resilience of diverse farming systems in the Mount Kenya Region.

From October 28th to November 11th, The students will take part in a field course in the Mount Kenya Region. Students will then gain practical knowledge on field, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

**Prerequisites / notice**

We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 18rd 2023, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

**Competencies**

**Subject-specific Competencies**

Concepts and Theories: assessed
Techniques and Technologies: assessed

**Method-specific Competencies**

Analytical Competencies: assessed
Decision-making: fostered
Problem-solving: fostered
Project Management: assessed

**Social Competencies**

Communication: assessed
Cooperation and Teamwork: assessed
Leadership and Responsibility: assessed
Self-presentation and Social Influence: fostered
Sensitivity to Diversity: assessed
Negotiation: fostered

**Personal Competencies**

Adaptability and Flexibility: assessed
Critical Thinking: assessed
Integrity and Work Ethics: assessed
Self-awareness and Self-reflection: assessed
Self-direction and Self-management: assessed
Synergies, Practices and Policies

Limited to 20 students.

Abstract
In politics, society, and science, it can seem that the values and practices of agricultural production and environmental protection are in conflict. This tension is often described as “protection versus use” of natural resources. We will explore ways to move beyond the apparent conflict. We will apply this learning to field trips and transdisciplinary projects.

Objective
Students are able to:
- Define different kinds and categories of values.
- Relate value concepts to their own studies, life, and experiences through reflective journaling.
- Infer the underlying values in a text or policy about agri-environmental topics.
- Collaboratively develop a transdisciplinary project for an agri-environmental case study from the field trips.

Content
The course consists of interactive seminars alongside fieldtrips to farms that have found innovative solutions to balancing protection and production.

Seminars will cover topics such as the relationship between values and behavior and how people perceive value trade-offs. We will also discuss environmental ethics, environmental valuation and its critiques, the interplay of facts and values in agri-environmental decision-making, cultural ecosystem services, and relational values.

This class requires active participation. Learning is based on in-class activities, group work and fieldtrips.

Literature
Literature will draw from political ecology, value theory and environmental values, as well as case studies and primary texts, such as the following (not all will be required reading; we will read 1 or 2 papers or book chapters each week).


Environmental Values, by O'Neill, Holland and Light, 2008
IPBES Values Assessment 2023


Autonomous robots are quickly becoming a key player in the transition to precision agriculture. In this course, students will learn theoretical and practical aspects of robotics. Lectures will introduce how robots operate and analyse their application to precision agriculture. In hands-on laboratories, students will apply concepts learned in class on educational robots to simulate a weeding task.

The learning objectives of the course are: (i) illustrate the principle of operation of the main components of a robotic system, (ii) analyse how the different robotic components are integrated and contribute to the functioning of a robotic system, and (iii) solve problems in the field of agriculture using robotic principles.

### Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

### Prerequisites / notice
- 252-0840-02L Anwendungsnahes Programmieren mit Python
- 401-0624-00L Mathematik IV: Statistik
- 401-6215-00L Using R for Data Analysis and Graphics (Part I)
- 401-6217-00L Using R for Data Analysis and Graphics (Part II)
- 701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt Naturwissenschaften

### Literature

Class size limitation to 30 students.
Agroecology is a discipline, an agricultural practice, and a political-social movement. Students will attend public lectures by experts from different fields and will reflect on agroecology and its principles. Moreover, students will expand their knowledge with case studies and discusses about the role of agroecology to support sustainable agriculture and food systems.

Students will be able to transfer their disciplinary and interdisciplinary knowledge about the thirteen principles as guiding principles for policymakers, practitioners, and other stakeholders across the food system in planning, managing, and evaluating agroecological transformation. Students are part of small groups focusing on selected principles of the HLPE. During the course, students discuss the potential and limitations of agroecology and learn about scientific contributions to agroecology. Students form an opinion on the role of agroecology, reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

The course is designed as a combination of public lectures/webinars on "Agroecology and the Transformation to Sustainable Food Systems" delivered by national and international experts and scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a group work format. The public lectures bring different perspectives to the discussion and are intended as inputs for the students' sessions. In the student sessions, the student groups deepen their knowledge of the 13 principles of agroecology proposed by the High-Level Panel of Experts (HLPE) of the Committee on World Food Security. They identify "unknowns" and link to other closely related principles. The groups also work out the perspective of a chosen stakeholder. Finally, the groups will take part in a scientific discussion representing their stakeholder perspective. All groups will synthesize their discussions in a short report.

Hands-on involvement with the scientific community (e.g., under the guidance of agricultural science professors) will be an essential component. This will prepare students for successful career advancement in the field of agroecology, reflecting and arguing on the different facets and developing recommendations for real-world applications of agroecology in supporting transitions of sustainable food systems.

### Competencies

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### Literature


### Prerequisites / notice

This course is based on fundamental knowledge about plant ecophysiology, soil science, biogeochemistry, crop and forage science, and ecology in general. The course will be taught in English. The course is only offered in fall.

### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-1030-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

The Master thesis is an independent scientific work. Normally the subject is selected among the topics of the core subject. It is written under the guidance of a agricultural science professor.
We study the following chapters of the book Marschner’s Mineral Nutrition of Plants Fourth Edition 2023.

Objective
The course enables students to describe basic knowledge of human and animal anatomy and physiology, to understand basic functions of the organism, to understand connections between morphology and function of organ systems, to describe the development of organ systems and to be able to understand pathophysiological connections.

Literature
A detailed bibliography is included in the lecture notes.

Prerequisites / notice
Calculation exercises are part of the course. A calculator is required for this.

Comprehensiveness
Basics in Animal Nutrition

Content
Turnover and utilisation of nutrients and energy in the animal (definition of terms, turnover in the animal body, balances, utilisation).
Feed evaluation in cattle, pigs and poultry (energetic feed evaluation, evaluation of nitrogenous feed substance)
Nutrition of cattle, pigs and poultry (basics of feeding, physiological characteristics, demand and demand coverage, feeding standards, ration design)
Feed science (individual feedstuffs, farm-produced feed)

Lecture notes
Lecture notes are available and can be obtained by moodle.

Literature
A detailed bibliography is included in the lecture notes.

Prerequisites / notice
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Comprehensiveness
Plant Nutrition I

Content
We study the following chapters of the book Marschner’s Mineral Nutrition of Plants Fourth Edition 2023.

Lecture notes
We study the following chapters of the book Marschner’s Mineral Nutrition of Plants Fourth Edition 2023.

Literature

Comprehensiveness
Anatomy and Physiology of Humans and Animals I+II

Abstract
Imparts a basic understanding of physiology an anatomy in man and domestic animals, focusing on the interrelations between morphology and function of the organism, in particular of domestic animals. This is fostered by discussing all subjects from a functional point of view. The lecture consists of two consecutive parts.

Objective
The course enables students to describe basic knowledge of human and animal anatomy and physiology, to understand basic functions of the organism, to understand connections between morphology and function of organ systems, to describe the development of organ systems and to be able to understand pathophysiological connections.

Literature
A detailed bibliography is included in the lecture notes.

Prerequisites / notice
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Comprehensiveness
Basics in Animal Nutrition

Content
Turnover and utilisation of nutrients and energy in the animal (definition of terms, turnover in the animal body, balances, utilisation).
Feed evaluation in cattle, pigs and poultry (energetic feed evaluation, evaluation of nitrogenous feed substance)
Nutrition of cattle, pigs and poultry (basics of feeding, physiological characteristics, demand and demand coverage, feeding standards, ration design)
Feed science (individual feedstuffs, farm-produced feed)

Lecture notes
Lecture notes are available and can be obtained by moodle.

Literature
A detailed bibliography is included in the lecture notes.

Prerequisites / notice
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Introduction to Crop and Forage Production

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
This course provides an introduction into crop and forage sciences - with a focus on sustainable management methods in Switzerland and Europe.

Objective
The students know the basic processes and management methods of arable and forage production in Switzerland and Central Europe. They know the most relevant arable crops. Students can assess the influence of environmental factors and management not only on individual plants, but also on meadow and pasture plant communities and on their yields. They understand the relevance of crop rotation measures and can make recommendations for the establishment of land management methods. The students are familiar with sustainable, climate-friendly and biodiversity-conserving or biodiversity-enhancing management measures and understand the value of species-rich vegetation for the provision of ecosystem services.

Content
The lecture is divided into two parts, i.e., Arable Crop and Forage Production, supervised by different lecturers.

The part 'Arable Crop Production' deals with the most relevant arable crops and with basic steps of arable field management such as soil tillage, sowing and plant protection. Effects on soil structure, different tillage measures for different crops as well as differences in the intensity of intervention in comparison of conventional and soil-conserving tillage (e.g. no-till) are explained. The most important differences between conventional, integrated and organic production are addressed. Special emphasis is placed on the establishment of crop rotations taking into account the farm context.

In the part 'Forage Production', important plant functional groups and representative plant species as well as different types of grassland systems, i.e., most important mixtures as well as natural plant communities in Central Europe are presented (ward assessment). Based on the ecophysiology of individual plants, the reactions of plant stands to changing environmental conditions are elaborated. Different types of management are presented (e.g. fertilisation, grazing, cutting) and their effects on stand composition and yields are discussed. Feedback mechanisms between environment and grassland systems are addressed. The role of biodiversity is addressed.

Animal Breeding

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to basics of animal breeding. Importance of animal production. Species of livestock and their products, performance recording, functional traits, genetic diversity, breeding goals. Qualitative and quantitative traits. Basic knowledge of breeding methods: genetic and environmental variation, heritability, genetic correlation, estimation of breeding values, selection, mating systems.

Objective
Show the importance of animal production for Swiss and international agriculture. Name the livestock species, their products, systematic classification and breeding and production goals. Describe methods to measure animal performance (performance recording) and functional traits. Define the most important parameters and methods in animal breeding.

Content
Domestication, history of animal breeding.
Definition, models of animal production, species of livestock, numbers, distribution.
Genetic polymorphisms and their applications in animal breeding.
Genetic diversity, breeds, production and breeding goals.
Qualitative (monogenic) and quantitative (polygenic) traits, Mendelian genetics, quantitative genetics.
Genetic and environmental variation, heritability, genetic correlation, selection, selection response.

Lecture notes
Transparencies and single chapters of textbook are made available on homepage.

Literature
Tierzucht (William/Simianer) UTB 3526 (2011)
Additional literature to be announced in the lecture.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods and Technologies</th>
<th>Assessed</th>
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<td>Concepts and Theories</td>
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<td>Analytical Competencies</td>
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<td>Project Management</td>
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<td>Adaptability and Flexibility</td>
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<td>Fostered</td>
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<td>Critical Thinking</td>
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<td>Self-direction and Self-management</td>
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Agricultural Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
<th>Z</th>
<th>Courses outside the curriculum</th>
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<tr>
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<td>Dr</td>
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### Key for Hours

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<td>V</td>
<td>lecture</td>
<td>European Credit Transfer and Accumulation System</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td></td>
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<tr>
<td>S</td>
<td>seminar</td>
<td></td>
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<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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Special students and auditors need special permission from the lecturers.
Applied Geophysics Master
Courses at ETH Zurich only take place in Spring Semester.

<table>
<thead>
<tr>
<th>Applied Geophysics Master - Key for Type</th>
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<tr>
<td>W</td>
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<tr>
<td>Z</td>
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<td>V</td>
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<td>G</td>
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<td>seminar</td>
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<tr>
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ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
Architecture Bachelor
► First Year Examinations
►► Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>052-0603-00L</td>
<td>Structural Design I</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>P. Block</td>
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</tbody>
</table>

**Abstract**
The courses Structural Design I and II explain the fundamentals of how structures function. These courses put great emphasis on studying the relationship between the form of a structure and the internal forces within it by means of graphic statics.

**Objective**
At the end of the courses Structural Design I and II, students will be able to:
1. visualize the internal forces within structural elements.
2. understand the relationship between the form of a structure and the internal forces within it.
3. modify the design of a structure in order to improve it.
4. identify the most important structural typologies.
5. use graphic statics for the form-finding and analysis of structures.
6. carry out basic dimensioning of structural elements.
7. respond to structural problems in a creative manner.

**Content**
Structural Design I:
- Fundamentals of static equilibrium
- Introduction to graphic statics
- Basic dimensioning of structural elements
- Cables and stiffening schemes of cables
- Arches and stiffening schemes of arches
- Arch-cables structures

Structural Design II:
- Trusses
- Beams
- Frames
- Plates
- Buckling of compression elements

**Literature**
"The art of structures, Introduction to the functioning of structures in architecture"  

"Faustformel Tragwerksentwurf"  
(Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2013, ISBN: 978-3-421-03904-0)

"Form and Forces: Designing Efficient, Expressive Structures"  

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

**Social Competencies**
- Negotiation

**Personal Competencies**
- Creative Thinking
- Critical Thinking

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>052-0703-00L</td>
<td>Sociology I</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>C. Schmid, N. Bathla</td>
</tr>
</tbody>
</table>

**Abstract**
Sociology I investigates the relation between social developments and the production of the built environment from a macro-sociological point of view. It examines central aspects of social change, historical and contemporary forms of urbanization, and typical examples of models of urbanization.

**Objective**
This series of lectures should enable students to comprehend architecture in its social context.

**Content**
Sociology I deals with the macro-sociological point of view, and investigates the relation between social developments and the production of the built environment. In the first part central aspects of social change are examined, in particular the transition from Fordism to Neoliberalism and the interlinked processes of globalization and regionalization. The second part deals with historical and current forms of urbanization. Among other aspects, it focuses on the changed significance of the urban-rural contradiction, the processes of suburbanization, periurbanization, and planetary urbanization; the formation of global cities and metropolitan regions; the development of new urban configurations in centres (gentrification) and in urban peripheries (edge city, exopolis, new urban intensity). In the third part these general processes are illustrated by typical models of urbanization: Manchester, Chicago, Los Angeles, Paris and Zürich.

**Literature**
A detailed collection of original texts will be distributed.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>052-0901-00L</td>
<td>Building History I</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>J. Schäfer</td>
</tr>
</tbody>
</table>

**Abstract**
History of building from classical antiquity to modernity: building types, constructions, forms, with particular reference to functional issues such as flexibility of use, statics, durability. This is not a mere history lecture, but an important part of the basic introduction into construction.

**Objective**
Participants know the fundamentals of building history, including landmark monuments of each era, key historic constructions and forms. They are able to "read" a historic building and to relate it to building history. They are aware of the variety of historic building constructions.
### Content

Building history I covers the period from classical Greek antiquity to medieval architecture. The principal topics include construction issues such as Greek megalithic building, Roman mortar-and-rubble construction, and vaulting.

Within the Vitruvian and Albertian triad of firmitas, utilitas and venustas, we focus on the first two topics, whereas the last topic (deciphering the "meaning" of architecture) stands at the heart of the "architectural history" lectures. The present lecture contributes essentially to deepening knowledge about historic constructions, an indispensable precondition for building within existing fabric.

- buildings of Greek antiquity as examples of construction with huge stone blocks
- Roman buildings as examples of building with small materials, strict functional disposition, and evolution of the art of vaulting
- late antique and early Christian buildings: discovering interior space, developing new paradigms for religious architecture, construction wide-span roofs
- early and high medieval construction, continuing antique traditions, revival of dressed stone and vaulting
- small buildings, notably rural housing
- the medieval monastery

### Lecture notes

Please keep a tight record of manuscript notes yourself. pdfs of lecture slides will be on line before each lecture. Lecture notes for exam preparation are provided and should be used in conjunction with the pictures from the lecture slides.

The exam will be held at the end of the first year. It is a computer-based multiple choice test. It calls for precise knowledge of the examples presented in the lecture, including the specifics of the architecture and construction of the buildings. Terminology is in GERMAN.

Will be announced during the lectures.

Due to professor Holzer's sabbatical, this lecture will be given by Dr. Jasmin Schäfer, in Fall Term 2024. However, the contents will be identical to the lecture delivered by professor Holzer in the Fall Term of 2023. This includes the topics, slides, lecture notes. Professor Holzer's lecture of Fall Term 2023 is available as a recording on video.ethz.ch. The lecture of Dr. Schäfer in Fall Term 2024 will NOT be recorded. Please refer to the recording of Fall Term 2023 under video.ethz.ch.

You may either listen to the fall 2023 recordings, to Dr. Schäfer's live lecture, or to both, to be prepared for the spring term of 2025 and the exam.

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>- Concepts and Theories</td>
<td>- Techniques and Technologies</td>
<td>- Communication</td>
<td>- Adaptability and Flexibility</td>
</tr>
<tr>
<td>- Analytical Competencies</td>
<td>- Decision-making</td>
<td>- Cooperation and Teamwork</td>
<td>- Negotiation</td>
</tr>
<tr>
<td>- Media and Digital Technologies</td>
<td>- Problem-solving</td>
<td>- Customer Orientation</td>
<td>- Critical Thinking</td>
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<tr>
<td>- Problem-solving</td>
<td>- Project Management</td>
<td>- Leadership and Responsibility</td>
<td>- Integrity and Work Ethics</td>
</tr>
<tr>
<td>- Project Management</td>
<td>- Self-presentation</td>
<td>- Self-awareness and Social Influence</td>
<td>- Self-awareness and Self-reflection</td>
</tr>
<tr>
<td>- Self-presentation and Social Influence</td>
<td>- Sensitivity to Diversity</td>
<td>- Self-direction and Self-management</td>
<td>- Self-direction and Self-management</td>
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</table>

### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0803-00L</td>
<td>History and Theory of Architecture I</td>
<td>O</td>
<td>2</td>
<td>2V+2U</td>
<td>T. Avermaete, C. Rachele, L. Stalder, P. Ursprung</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction and overview of the history and theory of architecture from the Renaissance to the nineteenth century. The course covers the chronology and key works, protagonists and discourses of early modern European architecture.

Fundamentals for the History and Theory of Architecture II-II offers a practical introduction to the methods and instruments of the history of art and architecture.

**Objective**

1. Acquiring basic knowledge of the history and theory of architecture during the early modern period, of its key protagonists and discourses and of the methods and instruments of architectural research.
2. Identifying the main architectural issues and debates of the period and recognising the places and architectural works covered in the course.
3. Acquiring the tools to develop a historically informed reading of the built environment, recognising debates, styles, ideas and problems which drive and inform architectural production.
4. Developing the tools to draw on historical, theoretical and critical research to the benefit to one's own architectural culture.

**Content**

The course History and Theory of Architecture II-II offers a chronological and thematic overview of the architecture and architectural theory produced in Europe from the 15th to the 19th centuries. Thematic lectures about key questions at play during the period will be combined with in-depth analysis of historical buildings, texts and iconographies.

Themes will cover the emergence and development of Vitruvian design and practice up to the 19th century and related issues such as the emergence of the architect; the development of original design practices and of divergent theories of architectural composition and design; the media of architectural design and practice (drawings, models, building materials); patterns and media of dissemination and influence (books, imagery, micro-architecture); building types (the palazzo and the villa); questions of beauty and ornament; questions of patronage (e.g., the Roman papacy) and the formation of religious and political symbolism through architecture; the relation of buildings to the city (e.g. the development of European capitals); attitudes towards history (origin myths, historicism); the question of the monument.

The exercises Fundamentals of the History and Theory of Architecture II-II aim to explore and develop basic methods and strategies to research the history of art and architecture. They consist of four parts, each developed under one of the four gta Chairs and each dealing with a particular area of study in the field of architecture and art history.

1. The historiography of architecture (M. Delbeke)
2. Architectural media (L. Stalder)
3. Architecture and art (P. Ursprung)
4. Urbanism and the Commons (T. Avermaete)
Literature
Course scripts, PowerPoints and lecture recordings for History and Theory of Architecture I-II will be available to download from the course page. Printed copies of the course scripts will also be available for purchase.

Prerequisites / notice
For the course History and Theory of Architecture I-II students will rely on assisted self-study to acquire basic knowledge of the history of architecture in Europe.

Competencies
Subject-specific Competencies | Concepts and Theories | assessed
--- | --- | ---
Method-specific Competencies | Analytical Competencies | assessed
Personal Competencies | Critical Thinking | assessed

| 052-0601-00L | Building Materials I | O | 2 credits | 2V | J. Pauli |
--- | --- | --- | --- | --- | --- |
Abstract
Building Materials - Introduction to the most common building materials
- Raw materials + Production
- Properties + Application
- Ecological footprint + Recycling

Objective
The lecture develops an understanding of different building materials and its application for construction under the aspects of material properties and ecological aspects.

Content
The lecture introduces the most common building materials concrete, steel, masonry and timber, but also clay, glass and polymers in a historical context. The fabrication processes are described and the most important properties regarding construction explained. A special focus is on the ecological aspects such as availability of raw materials, effort for production, emission of hazardous substances, disposal and recycling.

Lecture notes
Lecture slides as pdf

Competencies
Subject-specific Competencies | Concepts and Theories | fostered
--- | --- | ---
Techniques and Technologies | assessed
Method-specific Competencies | Analytical Competencies | assessed
Decision-making | fostered
Media and Digital Technologies | fostered
Problem-solving | fostered
Social Competencies
Communication | fostered
Leadership and Responsibility | fostered
Personal Competencies
Adaptability and Flexibility | fostered
Creative Thinking | fostered
Critical Thinking | fostered
Integrity and Work Ethics | fostered
Self-awareness and Self-reflection | fostered
Self-direction and Self-management | fostered

| 052-0605-00L | Computational Design I | O | 2 credits | 2V | B. Dillenburger, A. Savov |
--- | --- | --- | --- | --- | --- |
Abstract
This course introduces computational design and teaches how design can be modeled and materialized using digital technology. Participants learn to use the computer strategically, thoughtfully, and sensitively within the design process. With the “digital literacy” acquired in this course, they develop an understanding of the potential of a digital building culture.

Objective
To systematically harvest the potential of the computer in their work processes, architects need an insight into the fundamental principles of information technology. In this course, students learn the concepts, methods, and instruments of computational design. By the end of the two semesters, students will have mastered the basics of 3D modeling techniques, parametric design, programming code for Computer-aided-design (CAD), and digital prototyping. The acquired knowledge qualifies students to use the computer as a unique instrument to model their designs. Participants also learn to apply CAD and programming code creatively and productively in planning, design, and construction.

Specifically, the learning goals are:
- Critical understanding of the possibilities of information technology in design
- Acquiring an overview of the mechanisms and types of CAD systems and digital building models
- Gaining knowledge of the basic principles of computational geometry
- Applying visualization techniques and creatively using various digital media
- Learning concepts and application of parametric design, being able to integrate computer-aided analysis and optimization methods in design-process
- Understanding the principles of digital process chains from design to production
- Strategically using visual programming code
- Reading, understanding, and adapting programming code within CAD software.
The course is titled Perspectives on Landscape and Urban Transformation I+II. By bringing forward the term 'landscape' the course represents and collectively shape our environment. This is the first course which is collectively organized by the Institute of Landscape and Urban Studies (LUS), with the NEWROPE chair taking up the coordination. It will span two semesters.

Students will be provided with a reader at the first lecture. The reader for the course Perspectives on Landscape and Urban Transformation I+II is a container which holds together a collection of different hand-outs, brochures, and materials. All in all, it is a 'bag' and a personal organizer which invites students to fill over the course of the year. It allows them to individually structure and curate the content of the course. It is deliberately designed to be open-ended and to be individually extended and adapted. Towards the end of the semester, students will get a glossary where all key terms and concepts, presented in the various lectures, are combined. Each week students will receive a small leaflet that gives an overview of the individual lecture, as well as an additional reading.

Course Structure
The course consists of theoretical lectures, practical tutorials introducing technical concepts, and exercises supported by tutors. Participants can find updated and detailed information on Moodle, which is the learning platform for the course.

**052-0709-00L Perspectives on Landscape and Urban Transformation I
This learning unit replaces the old learning unit 052-0709-00L Urban Design I**

**Abstract**
In this course we will collectively explore the different actions and actors, as well as the roles and professional practices that represent and collectively shape our environment. This is the first course which is collectively organized by the Institute of Landscape and Urban Studies (LUS), with the NEWROPE chair taking up the coordination. It will span two semesters.

**Objective**
Through the different Perspectives on Landscape and Urban Transformation, students will learn to understand the complexity of the (urban) landscape. The various perspectives, readings and key terms will enrich and expand the vocabulary and theoretical knowledge of students. Tools for observation and activation will give students agency to observe and intervene in processes of urban transformation.

At the end of the course students will be able to perceive and identify a multitude of actors and professional roles and recognize how they are overlapping, entangled and ever-shifting. Students will practice to textually and visually illustrate complex processes, including the many different stakeholders involved and the notion of time. Students will learn to reflect about and formulate their possible personal positions in relation to others. The formulated learning goals are aligned with the teaching activities, the exercises, and the final evaluation.

**Content**
The course is titled Perspectives on Landscape and Urban Transformation I-II. By bringing forward the term 'landscape' the course stresses the need to put the natural environment and the landscape at the core of urban thinking. Accordingly, every architect requires a basic knowledge of the landscape and nature. Also, to focus on 'urban transformation', instead of 'urban design' is a conscious choice. It comes out of the recognition that materials, energy and space are finite, which forces us to engage first with what is already there, instead of producing even more new things.

This course presents designers as facilitators of complex urban transformation processes. This position requires both an understanding of a great diversity of perspectives and positions constituting a city, and of the different professional roles one can take up to detect and utilize this diversity of – specific and often conflicting – needs, wishes, ambitions and actions. In each lecture one of these perspectives is presented. The list of different perspectives presented in both semesters is deliberately left incomplete, leaving space for students to think of other perspectives, needs and desires that one could take into account when working on a design or (redevelopment) of a space.

Students will be provided with a reader at the first lecture. The reader for the course Perspectives on Landscape and Urban Transformation I-II is a container which holds together a collection of different hand-outs, brochures, and materials. All in all, it is a 'bag' and a personal organizer which invites students to fill over the course of the year. It allows them to individually structure and curate the content of the course. It is deliberately designed to be open-ended and to be individually extended and adapted. Towards the end of the semester, students will get a glossary where all key terms and concepts, presented in the various lectures, are combined. Each week students will receive a small leaflet that gives an overview of the individual lecture, as well as an additional reading.

All documents can be downloaded via moodle.

**Lecture notes**
Weekly handout of readings. All documents can be downloaded via moodle.

**Literature**
The course takes place at the Fokushalle, E7, ONA Building from 18:15h-20:15h.

The course will be under the formal responsibility of Prof. Freek Persyn and collectively coordinated by a core team consisting of Freek Persyn, Michiel van Iersel, Lukas Fink and Charlotte Schaeben.

Students can contact:
Charlotte (schaeben@arch.ethz.ch) for organisational, technical and personal questions
Lukas (fink@arch.ethz.ch) for questions regarding the reader, weekly exercises and the final exam
Michiel (mvaniersel@arch.ethz.ch) for questions regarding guests and literature
### Competencies

<table>
<thead>
<tr>
<th>Category</th>
<th>Competencies</th>
</tr>
</thead>
</table>
| Subject-specific Competencies  | Concepts and Theories assessed  
|                                | Techniques and Technologies assessed                                      |
| Method-specific Competencies   | Analytical Competencies assessed  
|                                | Decision-making fostered  
|                                | Media and Digital Technologies fostered  
|                                | Problem-solving assessed  
|                                | Project Management fostered                                                 |
| Social Competencies            | Communication fostered  
|                                | Cooperation and Teamwork fostered                                           |
|                                | Leadership and Responsibility fostered                                       |
|                                | Self-presentation and Social Influence fostered                              |
|                                | Sensitivity to Diversity assessed                                            |
| Personal Competencies          | Adaptability and Flexibility fostered                                       |
|                                | Creative Thinking assessed                                                  |
|                                | Critical Thinking assessed                                                  |
|                                | Integrity and Work Ethics fostered                                          |
|                                | Self-presentation and Self-reflection fostered                               |
|                                | Sensitivity to Diversity assessed                                           |
|                                | Negotiation fostered                                                        |

### Subjects with Semester Grade

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0501-00L</td>
<td>Design and Construction I</td>
<td>O</td>
<td>8</td>
<td>4V+10G+2U</td>
<td>A. Deplazes, D. Mettler, D. Studer</td>
</tr>
</tbody>
</table>

#### Course Description

**Abstract**

Designing and constructing will be understood to be a complementary offer. The content and methodical foundations of design and construction are taught and deepened through lectures and exercises.

**Objective**

Understanding and dominating the methodology of designing and constructing.

**Content**

Lectures and exercises to achieve the methodology and ability of designing and constructing.

**Lecture notes**


**Literature**

- Ed. Andrea Deplazes
- German, English, French, Spanish
- ISBN 978-3-0356-1669-9

Further Literature will be published in the lectures.

**Prerequisites / notice**

100% of interest and engagement!

Participation in the seminar week of the Deplazes chair ("Hybrid Modeling") from DATE is compulsory!
Art in Space and Time I

Project grading at semester end is based on the list of enrolments on x.xx.2024 (valuation date) only. This is the ultimate deadline to unsubscription or enrol for the studio.

8 credits 5G+4U  R. Barba, H. E. Franzen, M. Narula

Abstract
Attendance in the lecture and exercise "Art in Space and Time I" and in the course "Introduction to Free and Perspective Drawing". Submission of artistic exercise works. The semester grade results from participation in the lecture and exercise "Art in Space and Time I" as well as the "Introduction to Free and Perspective Drawing", and the submission of artistic exercise works.

Objective
Students engage in experimental concepts in the arts as well as free and perspective drawing. In addition to acquiring extended artistic thought processes and practices, they each develop their own artistic exercise works.

Content
"Art in Space and Time" encompasses diverse and multi-disciplinary research fields, ranging from urban anthropology to artistic practices: film, sculpture, sound, writing, digital arts, and performance. These fields include and intersect with language, political discourses, and investigations of the human environment. Concrete theoretical as well as speculative, practical procedures are being tested to open up new horizons of perception and to reflect on them.

Examination Blocks

052-0503-00L  Art in Space and Time I  O  8 credits  5G+4U  R. Barba, H. E. Franzen, M. Narula

Abstract
Attendance in the lecture and exercise "Art in Space and Time I" and in the course "Introduction to Free and Perspective Drawing". Submission of artistic exercise works. The semester grade results from participation in the lecture and exercise "Art in Space and Time I" as well as the "Introduction to Free and Perspective Drawing", and the submission of artistic exercise works.

Objective
Students engage in experimental concepts in the arts as well as free and perspective drawing. In addition to acquiring extended artistic thought processes and practices, they each develop their own artistic exercise works.

Content
"Art in Space and Time" encompasses diverse and multi-disciplinary research fields, ranging from urban anthropology to artistic practices: film, sculpture, sound, writing, digital arts, and performance. These fields include and intersect with language, political discourses, and investigations of the human environment. Concrete theoretical as well as speculative, practical procedures are being tested to open up new horizons of perception and to reflect on them.

Examination Blocks

052-0607-00L  Structural Design III  O  2 credits  3G  J. Pauli

Abstract
The course Structural Design III complements the courses Structural Design I and II by introducing building materials and construction techniques.

Objective
After a successful conclusion of the course, students will be able to:

1. Understand the structural behaviour of a building and of its main components
2. Conceive and control design parameters as part of the design process
3. Design structural systems in compliance with diverse performance criteria including architectural, structural, constructive, and environmental aspects altogether.
4. Design structural systems consistent with the material used
5. Dimension structural elements using different building materials
6. Develop construction details in compliance to a specific static scheme
Content

The course presents a holistic approach to the design of structures by integrating static equilibrium, learned in previous semesters, with considerations regarding materials and construction techniques.

The course explores the relationship between architecture and structure by introducing and discussing design parameters and their implications with respect to different performance criteria. In addition to those related to statics, performance criteria also include aspects related to use of material and energy resources, which is directly connected to questions of environmental footprint.

The objective of the course is to show that structural design tasks must consider a number of aspects belonging to different disciplines simultaneously. This results in a level of complexity that very rarely can be reduced to a univocal “right” answer. Critical thinking and technical knowledge must support each other. The course aims at giving the tools for developing these skills.

After a brief review of the key aspects taught in Structural Design I and II, the course Structural Design III will examine different load-bearing elements, how they relate to each other, and their possible relationships with the architectural space.

Starting from 2D spanning structures, a series of 5 lectures will illustrate the functioning of the main load-bearing elements of multistory buildings by means of graphic statics as well as analytical methods.

Implications at the level of structural performance, spatial performance, material use, and environmental footprint will be thoroughly discussed throughout the entire course by analyzing buildings of exemplary quality.

The content of the lectures will be strengthened through 5 exercise sessions during which students will apply the knowledge gained during the lectures and refine their design skills through dedicated design exercises under the supervision of a tutoring team.

Literature

"The art of structures. Introduction to the functioning of structures in architecture"

"Faustformel Tragwerksentwurf"
(Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2013, ISBN: 978-3-421-03904-0)

"Form and Forces: Designing Efficient, Expressive Structures"

Prerequisites / notice

To take part in this course, it is recommended to first complete the courses Structural Design I and II or to have knowledge of graphic statics.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Decision-making</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td></td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Negotiation</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
</tr>
</tbody>
</table>

Prerequisites / notice

To take part in this course, it is recommended to first complete the courses Structural Design I and II or to have knowledge of graphic statics.

Abstract

This two-semester course is an introduction to the history of architecture from the Second Industrial Revolution in the 1850s to the Oil Crisis in the 1970s in Europe. Students will be able to identify the “things”—technical objects and ensembles—that transformed architecture, and to relate them to the technical, scientific, and cultural concerns that introduced them as key features of modernity.

Objective

To introduce students to the history and theory of architecture, the course has three objectives. First, students will be able to identify the “things” that transformed architecture in modernity, and the crucial events, buildings, theories, and actors that characterize their history.

Second, students will be able to describe how these “things” operated at different scales, focusing less on the formal level, and naming instead the different forms of expertise that constituted them historically, as well as the processes within which they were embedded.

Third, students will be able to reflect on a series of apparatuses, devices, and building parts that are in fact micro-architectures which have often been neglected, despite their pivotal role in shaping the daily lives of modern societies.

Content

The course proposes a new approach to the study of the history and theory of architecture in Europe during modernity. It focuses less on single architects or their buildings, and more on those “things” that have brought profound transformations in the built environment and daily life over the last 200 years, such as the revolving door, the clock, and the curtain.

The notion of “thing” includes both the concrete building parts and the concerns associated with them, such as material performance, social synchronization, and individual expression. To understand buildings as assemblages of “things,” therefore, does not mean to diminish their significance, but on the contrary to add reality to them, to understand them in terms of the complex, historically situated, and diverse concerns within which they were designed.

Each lecture introduces one “thing” through a genealogy that shaped it, from patents and scientific discoveries and technological advancement, to cinema, the visual arts, and literature. A set of renowned projects as well as lesser-known buildings from all around Europe offers a variety of case studies to describe these “things,” to understand how they operated in relation with one another, and to identify the theories and tactics that architects mobilized to make sense of them.

Lecture notes

http://www.stalder.arch.ethz.ch/courses
Subject-specific Competencies

This class builds on the digital literacy foundations taught in the previous year and expands the acquired competence in the use of computers in design. At the core stands the question of how to use digital architectural design methods in a creative, purposeful and self-confident manner.

Concepts and Theories

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Computational Design III

Title of this course before HS22: "Mathematical Thinking and Programming III".

Abstract

This class builds on the digital literacy foundations taught in the previous year and expands the acquired competence in the use of computers in design. At the core stands the question of how to use digital architectural design methods in a creative, purposeful and self-confident manner.

Objective

The course consists of lectures and exercises. The lectures convey an insight into strategies for the implementation of algorithmic techniques in architectural design by presenting and discussing the research and the build work of the professorship. This pragmatic view on the computational design process helps demystifying algorithmic techniques and developing a critical understanding for their potentials in the architectural praxis. Programming is an extension of traditional design tools. While this powerful cultural technique allows us to handle complexity in a previously unknown way, the question of its meaning, relevance and potential needs to be negotiated on a context specific base for every single project. In order to be able to do this, we shall develop a conceptual understanding for the methods as well as familiarity with the practice of programming. While the works discussed in the lectures sharpen the conceptual understanding, the tutored exercises will train the programming practice. In these sessions, we will implement simplified yet powerful versions of the discussed projects by using Rhinoceros 3D as a modeler and Grasshopper as a visual programming interface, both environments that have been introduced in the previous semesters. Up-to-date and detailed information on the lectures and exercises is announced on MOODLE, which will serve as the teaching platform for this course.

The specific learning goals are:

• To develop a critical awareness for the potentials of algorithmic design methods.
• Learn to deploy parametric design strategies.
• Become familiar with the practice of visual programming.
• Understand the concepts and potentials of digital fabrication.

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-8009-00L</td>
<td>Building Physics II</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>J. Carmeliet, M. Ettlin, A. Rubin</td>
</tr>
<tr>
<td>Abstract</td>
<td>Moisture related problems are common in buildings leading to costly damage and uncomfortable indoor environments. This course aims at providing the necessary theoretical background and training in order to foresee and avoid these problems. To develop a basic understanding of mass transport and buffering to become aware of potential moisture-related damage and health risks to learn how to (i) design building components and (ii) assess their hygrothermal performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>• hygrothermal loads • conservation of mass (dry air, water vapor, liquid water) • moist air: constitutive behavior, transport, potential problems and solutions • liquid water: constitutive behavior, transport, potential problems and solutions exercises</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Handouts, supporting material and exercises are provided online via Moodle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites/notice</td>
<td>Prior knowledge of &quot;BP I: heat&quot; is required.</td>
<td></td>
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</tr>
</tbody>
</table>

Global History of Urban Design I

This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

Objective

The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.
In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

01. The History and Theory of the City as Project
02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
03. The Idea of the Polis: Rome, Greece and Beyond
04. The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
05. Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
06. Of Absolutism and Enlightenment: Baroque, Defense and Colonization
07. The City of Labor: Company Towns as Cross-Cultural Phenomenon
08. Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
09. Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
10: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed

Personal Competencies
- Negotiation: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered

There are three books that will function as main reference literature throughout the course:


Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

There are ten research domains in the course: 01. The History and Theory of the City as Project, 02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus, 03. The Idea of the Polis: Rome, Greece and Beyond, 04. The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi, 05. Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles, 06. Of Absolutism and Enlightenment: Baroque, Defense and Colonization, 07. The City of Labor: Company Towns as Cross-Cultural Phenomenon, 08. Garden Cities of Tomorrow: From the Global North to the Global South and Back Again, 09. Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham, 10: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid.

These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).


Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).
The building process is the main focus of this lecture series. The process is understood as a sequence of criteria in time.

Concepts and Theories

The learning material, available via https://moodle-app2.let.ethz.ch/is comprised of:
- Toolbox 'Reader' with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings
- Reading material will be provided throughout the semester.

Data: 02.07.2024 12:39
Autumn Semester 2024
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### Objective

The course provides the basics and tools for an in-depth understanding of the discipline of landscape architecture and its far-reaching interconnections with architecture, urban planning, ecology and other spatial and nature-related sciences. The aim is to adopt landscape perspectives in planning and design processes and to critically reflect on one's own projects within a specific context. Students learn about historical developments and their topicality and learn "from history". Design contexts are presented on the basis of examples. Students develop a basis for ways of thinking and action for current landscape architectural challenges.

### Content

The lectures in the fall semester course “History and Theory of Gardens and Landscape Architecture” provide an overview of the cultural history of nature, the landscape and the garden from its origins to the present day. An in-depth understanding of change as well as the design strategies and characteristics of the most important epochs and their current relevance will be discussed.

### Lecture notes

Handouts and a bibliography will be provided

### Prerequisites / notice

General information on the examination:

Bachelor students: The knowledge taught in the lecture and the exam-relevant literature provided by the lecturer serve as the basis for exam preparation. The course is designed as an annual program. As the written session exam tests knowledge from both the Landscape Architecture I and II lecture series, it is strongly recommended that you attend the course over two semesters.

The examination topics will be announced shortly before the end of the semester. The lecturer will provide texts on the examination topics as pdf files for download. These serve to deepen understanding of the lecture.

Mobility students or students from other departments: Students who only attend the lecture for one semester complete the lecture with an end-of-semester oral examination.

Here too, the lecturer provides literature relevant to the examination as a download.

Students registered for the exam will receive further information on the exam procedure by email shortly before the end of the semester.

### Competencies

#### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

#### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

#### Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Leadership and Responsibility: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

#### Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### 052-0609-00L Energy and Climate Design I

**Abstract**

This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy, GHG emissions and climate with architectural and urban design will be investigated.

**Objective**

At the end of this one-year course, students will be able to estimate the impact of energy, GHG emissions and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform ([https://moodle-app2.let.ETHZ.ch/course/view.php?id=11917](https://moodle-app2.let.ETHZ.ch/course/view.php?id=11917)). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

**Content**

Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:

1. Local potentials
2. Demand
3. Supply

**Lecture notes**

The slides of the lecture on the course moodle serve as lecture notes and are available as download.

**Literature**

A list of relevant literature is available at the chair.

**Prerequisites / notice**

This course can only be taken if Energy and Climate Design II is taken in the following semester, as the group work is connected and extends throughout the year.

**Competencies**

#### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed

#### Social Competencies

- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: assessed
- Sensitivity to Diversity: assessed

#### Personal Competencies

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-direction and Self-management: assessed

### 052-0507-00L Architectural Technology V

**Abstract**

Construction is the prerequisite for making an architectural, spatial idea tangible in the first place. In this lecture series, it is understood as a component of a holistic, coherent architecture and is derived from its architectural, spatial context on the basis of a broad selection of buildings.

**Objective**

...
Objective

The lecture series does not provide instructions or recipes on general constructive topics. The description of distinctive, spatial experiences and the constructive measures used to achieve them, is rather intended to sharpen the students' awareness, for their own design work and to show countless possibilities of how an architectural, spatial idea can be understood and further developed through its material, its construction method and its supporting structure.

Content

The buildings, which are described and explained in the lectures, differ fundamentally from each other in their time of origin, their urban context, as well as their geographical location and could hardly be more different in their scale and their use. These buildings are not a typical expression of their time and location, instead they are an expression of an individual creation and likewise use the constructive possibilities of their time and their environment in a distinctive way. Accordingly, each lecture is dedicated to a different architect.

In addition, isolated current examples from professional practice will be shown. These lectures on new buildings, some of them unfinished, are given by an architect directly involved on site, in English, and partly online.

23.09.24 Film
30.09.24 Artigas
14.10.24 Bloc
28.10.24 Modell und Wirklichkeit
11.11.24 Shinohara
25.11.24 Nov Le Corbusier

Lecture notes

The script is a comprehensive collection of material that allows students to form their own ideas about the case studies shown, independent of the lecture. Most of the photographs were taken on study trips and show the buildings under discussion with unpublished material. The extensive collection of photographs is supplemented with drawings, plans, site photographs, and historical photographs from books and archives. The script will be made available in digital form at the end of the year to students enrolled in the lecture series.

Prerequisites / notice

Mobility students or students from other departments who only want to take the exam on the material from the last semester (Construction V or VI) are asked to contact the chair in advance.

Competencies

Subject-specific Competencies

Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Self-awareness and Self-reflection assessed

► Architectural Design

►► Architectural Design (3. Semester)

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). Students who do not wish to change the design class don't have to participate in the internal enrolment. Project grading at semester end is based on the list of enrollments on 30.10.2024, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

Focusing on the theme of Shelter, the semester begins with a field trip to Rome, where we will visit and study selected historical examples. Through this analysis we will develop a typological understanding of architecture, addressing questions of space, structure and tectonics. The second half of the semester will be dedicated to the design of an ideal shelter located in the Roman countryside.

Objective

Design Studio "Architectural Design III":
Master the analysis of historical case studies through experimental drawings. Foster a multifaceted interpretation of architectural principles and characteristics, while developing an environmentally aware approach to design, and addressing climate issues on a typological level. Cultivate an understanding of the topic in relation to contemporary issues. Learning to address aspects related to form and tectonics within the design of a new building.

Lecture "Construction III":
Introducing students into different design and making approaches to find a path towards their personal approach on designing and making.
Design Studio "Architectural Design III":
In times of climate crisis and strong social transformation we find ourselves dwelling on unsettling questions: am I still safe in my place? Will there be room for everyone in the future? What is the minimum necessary to live? What does it take to foster an idea of community that is gradually disappearing? Within the discipline of architecture, such doubts and fears can be translated into fundamental design questions: how do we protect our living space from increasingly harsh and unpredictable climatic events? How do we design resilient and durable structures? How to make the best use of the limited available resources? All these questions take us back to the roots of architecture, to the complex relationship between nature and civilization, to the human need of finding refuge in and from nature: Shelter.

But what is Shelter? Not just a protection from natural elements, a shelter also identifies the place of collective refuge in our society, a place of community and hospitality. This social value in turn influences the architectural form: be it inn or church, hut or temple, cave or hangar, the Shelter is as much primary dwelling as cultural place. The Shelter is Architecture.

With these questions in mind, we will dedicate the coming studio in the series of Ideal Architecture to the development of a contemporary understating of Shelter, taking into consideration its connotation as both intimate and collective space, and its socio-cultural value: The Ideal Shelter - 7 new Types. Starting from historical examples, we will develop the basic architectural knowledge needed to tackle this challenging task in theory and practice. Primary questions of space, structure and tectonics, as well as the fundamental issues of proportion, form and meaning will be at the center of our design debate.

We will begin the design process for a new contemporary shelter with a field trip to Rome. We will visit, analyze and critically reflect on 7 shelters from different time periods. This will be followed by a visit to 7 sites outside of Rome. Here in the ideal (-ized) landscape of the Roman Campagna, the Ideal Shelter will find its place. As a studio we will collectively develop a culture of representation where multi-layered drawings and models, as well as the handling of historical references, will form the methodological basis for the design, which will primarily focus on typological, tectonic, and formal aspects.

Lecture "Construction III":
The overall topic of the lecture series is "Construction – Elements of Architecture". The lecture series gives the students an insight into different construction and design methods. The lectures are held by four different professorships in a block of 5 lectures in a row and showcasing their individual approach on design and architecture in general.

Literature
Lecture "Construction III":
Momoyo Kajjima:

Jan De Vylder:
Free to consult / not limited
- BRAVOURE SCARCITY BEAUTY – 9789082122572
- UNLESS EVER PEOPLE – ISBN 9789492567079
- GALLERY MAGAZINE N° I – ISBN 9789493146495
- PARTTIMEAMATEURTOURIST - INSTAGRAM

Emanuel Christ and Christoph Gantenbein:

Roger Boltshauser:
- Tschanz, Martin (2021): Roger Boltshauser, Monografie, Triest Verlag, Zurich.
- Hönger, Christian; Menti, Urs-Peter; et al. (2009): Das Klima als Entwurfsfaktor, Quart Verlag, Luzern.

Prerequisites / notice
Design Studio "Architectural Design III":
Group work.
Introduction:
Intermediate crits:
Final crits:

Lecture "Construction III":
Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Sensitivity to Diversity assessed
Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

Architectural Design III: House Behaviorology in Switzerland (M.Kajjima)
Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). Students who do not wish to change the design class must not enrol.

Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the
Abstract

Lecture "Construction III":
The overall topic of the lecture series is "Construction – Elements of Architecture". The lecture series gives the students an insight into different construction and design methods. The lectures are held by four different professorships in a block of 5 lectures in a row and showcasing their individual approach on design and architecture in general.

Objective

In the 2nd Year curriculum, three courses are related in design theory and design practice: "Konstruktion III" is design theory. "Konstruktion BUK III" is construction theory. "Architectural Design III" integrates the theories from the different courses including with them to apply architectural design in real-world problems.

Architectural Design III: House Behaviorology in Switzerland (M.Kaijima)

Typology and Research (4 weeks)
Each individual student
• is able to understand different housing typologies within their historical context. (2)
• is able to understand the principles of housing design, including topics such as Typology, Program, Usage, Privacy, Commonality, Material and Climate. (2)
• is able to independently gather information on a self-chosen topic (3)
• is able to analyze a case study house based on an individually formed question or individual interest. (4)
• is able to represent their analysis in a drawing and a short text. (3)

Structure and Space (4 weeks)
Each individual student
• is able to design a small-scale housing complex according to the above-mentioned principles. (3)
• is able to design spaces for privacy and for community. (3)
• is able to adapt a housing design to the needs of specific inhabitants with partially special needs, such as families and elderly. (3)
• is able to apply the principles of structural design to their housing design. (3)
• is able to critically evaluate a design and improve it. (5+6)
• is able to represent a design through floor plans, sections and elevations as well as with physical models (3)

Improving Design + Details and Construction (5 weeks)
Each individual student
• is able to detail a small-scale housing complex. (3)
• is able to understand the principles of construction. (2)
• is able to gather examples and evaluate them in accordance with their design (5)
• is able to evaluate and chose materials and construction in accordance with their design idea (5).
• is able to draw a section of their design in scale 1:50 with all necessary details. (3)

Cognitive scale
(1) Remember
(2) Understand
(3) Apply
(4) Analyze
(5) Evaluate
(6) Create
https://ethz.ch/content/dam/ethz/main/eth-zurich/education/lehrentwicklung/files_DE/Vorlage_LernzieleFormulierenDe.pdf

Grading Criteria:
The submissions will be graded before each review. Each submission is graded according to the following criteria:
• Completeness and punctuality of submission
• Research method, the ability to find and analyze information
• Implementation of the concept of Architectural Behaviorology within the design
• Choice of Typology, Design and Expression of the project, in connection with the concept of Architectural Behaviorology
• Structural design, construction details and choice of materials in accordance with the design idea and the method of Architectural Behaviorology
• Visualization, the ability to communicate a design effectively with compelling drawings, models and text.

The final grade consists of the following partial grades:
• Mid review 1 submission (individual work): 30%
• Mid Review 2 submission (individual work): 30%
• Final Review submission (individual work): 30%
• "Construction III" submission (individual work): 10%

Lecture "Construction III":
Introducing students into different design and making approaches to find a path towards their personal approach on designing and making. Last day of lecture, students must bring construction drawing by A5 sketchbook given at first lecture by design studio to submit the result of understanding of lectures. The presentation will be a large exhibition participated by all 2nd year students to share as exhibition by all 2nd year students. The result will be integrated in the grading of design studio.
**Content**

Architectural Design III: House Behaviorology in Switzerland (M.Kaijima)

Architectural Behaviorology and Actor Network Theory are our two guiding principles to not only design architecture but also understand our current existing environment.

By understanding a building, a house not as an isolated object but as a node in a vast and far reaching network, or several networks, we grow conscious of the impact, which our design has, not only on the specific plot but on the neighborhood, the city, the environment, society. Vice-versa, analyzing and understanding the relationships, which have shaped existing buildings, helps us to better understand how and why the design of those buildings came to be.

While identifying the relationship between actors within the network, we simultaneously observe the behavior of each actor as a result of their relationship. The behavior can be static or dynamic, actors can be human or inanimate. How does a building behave towards its environment? What behavior do inhabitants engage in within and around a building? How do we have to design to take Behaviors of certain materials into account?

House and Housing is the base of our living environment and a diverse field in architecture. House behaviorology will set the challenge to find sustainable living condition in the city, by understanding historical examples and their geography, density, economic standing, and time period.

At first, to find the character and essence of today's house and housing design in Ticino, we will start analyzing existing single-family houses in and around the city. We will research and map how these basic units of housing relate to the users, to each other and to their surroundings. What kind of purposes they fulfilled and what kind of activities and behaviors do these houses enable?

Second, we will try to improve on the design by changing the single-family house into housing complexes, responding to the need of greater density, but still retaining the qualities of the original houses. Where do we find synergies, when combining houses? What kind of common spaces arise and how can we make use of them to make better neighborhoods?

Simultaneously we will have a close look on designing for inclusivity. How do we design for partially special needs groups, such as the elderly or children? How can we all live together in a house and in the urban ecology?

**The course is structured as follow:**

**Typology and Research (4 weeks)**
- Analyzing an existing single-family house in Ticino according to the principles of Architectural Behaviorology and the historical context of the said house.
- Defining a special interest for an element or relationship between elements of the chosen house and defining a question as a tool to better understand this field of interest.
- Representing the house and the research in a large-scale drawing and a short text.

**Structure and Space (4 weeks)**
- Designing a housing complex with a given program on the basis of the analysis of the case study single-family house.
- Evaluating and adapting the design constantly.
- Applying the principles of structural design to the design project.

**Improving Design + Details and Construction (5 weeks)**
- Constantly improving the design and sharpening the design idea.
- Detailing one section in the scale of 1:50 by applying the learned principles of construction and structural design as well as adding details in accordance with the principles of Architectural Behaviorology.

**Lecture notes**

Architectural Design III: House Behaviorology in Switzerland (M.Kaijima) Lecture Notes

Each student will receive a printed reader, containing the basic information about the course, such as schedule, syllabus and other important information, as well as examples and references for the design task, and readings to support the theoretical framework of the course.

**Literature**

Architectural Design III: House Behaviorology in Switzerland (M.Kaijima)

- Atelier Bow-Wow, Behaviorology, Rizzoli International Publications, New York, 2010

Lecture "Construction III"

Momoyo Kaijima:
- Jan De Vylder:
  - Free to consult / not limited
  - BRAVOURE SCARCITY BEAUTY – 9789082122572
  - UNLESS EVERY PEOPLE – ISBN 9789492567079
  - GALLERY MAGAZINE N° I – ISBN 9789493146495
  - PARTTIMEAMATEURTOURIST - INSTAGRAM
  - Emanuel Christ and Christoph Gantenbein:
  - Roger Boltsheuser:
    - Tschanz, Martin (2021): Roger Boltsheuser, Monografie, Triest Verlag, Zurich.
    - Höniger, Christian; Menti, Urs-Peter; et al. (2009): Das Klima als Entwurfsfaktor, Quart Verlag, Luzern.

**Prerequisites / notice**

Architectural Design III: House Behaviorology in Switzerland (M.Kaijima)

To attend this course, students have to enroll through the "Enrolment in the Design Studios of D-Arch"-page: (www.einschreibung.arch.ethz.ch).

The design studio is structured as a year-long course.

The submissions during the autumn semester will be individual work.

Schedule Autumn Semester 2024:
- Introduction:
- Mid Review 1:
- Mid Review 2:
- Final Review:

Costs: ca. CHF

Location:

Lecture "Construction III":

Data: 02.07.2024 12:39
Autumn Semester 2024
Competencies

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Research and development of architectural themes resulting from energy and climatic considerations
- Practical work with models, plans and visualization programs as part of the design process
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

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**Architectural Design III: Material and Light**

***R. Boltshauser***

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). Students who do not wish to change the design class don't have to participate in the internal enrolment.

Project grading at semester end is based on the list of enrolments on 30.10.2024, 24:00 h (valuation date) only. This is also the ultimate deadline to unsubscribe or enroll for the studio.

**Abstract**

In the autumn semester, we will approach the phenomenon of space through fundamental experiences with regenerative materials and «Nordic Light» to design a cultural centre on Louis Kahn's home island of Saaremaa in Estonia.

In the spring semester, we work on the redensification of an industrial wasteland in Brunnen (CH) and focus on the themes of structure and place.

**Objective**

Semester topic "Design III":
- Addressing dense, sustainable, circular, simple building
- Development of a broad theoretical basic
- Holistic design of spatial atmospheres in the interplay of concept, context, construction, climate, sustainability and materiality
- Research and development of architectural themes resulting from energy and climatic considerations
- Practical work with models, plans and visualization programs as part of the design process

Lecture "Construction III":

Introducing students into different design and making approaches to find a path towards their personal approach on designing and making.

**Content**

Semester topic "Architectural Design III":

(...)

Lecture "Construction III":

The overall topic of the lecture series is "Construction – Elements of Architecture". The lecture series gives the students an insight into different construction and design methods. The lectures are held by four different professorships in a block of 5 lectures in a row and showcasing their individual approach on design and architecture in general.

**Lecture notes**

The students will receive a reader at the beginning of the semester.

**Literature**

Semester topic "Architectural Design III":

- Momoyo Kajima:

- Jan De Vylder:
  - Free to consult / not limited
  - BRAVOURE SCARCITY BEAUTY – 9789082122572
  - UNLESS EVER PEOPLE – ISBN 978942567079
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- Roger Boltshauser:
  - Tschanz, Martin (2021): Roger Boltshauser, Monografie, Triest Verlag, Zürich.
  - Boltshauser, Roger; Veillon, Cyril; Maillard, Nadja (2020): Piaè, Stampflehmbau – Tradition und Potenzial, Triest Verlag, Zürich.
  - Höniger, Christian; Menti, Urs-Peter; et al. (2009): Das Klima als Entwurfsfaktor, Quart Verlag, Luzern.
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<td>Media and Digital Technologies</td>
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<td>Sensitivity to Diversity</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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Techniques and Technologies: assessed

Decision-making: assessed

Media and Digital Technologies: assessed

Problem-solving: assessed

Project Management: fostered

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Communication: assessed

Cooperation and Teamwork: assessed

Self-presentation and Social Influence: fostered

Sensitivity to Diversity: fostered

Negotiation: fostered

Adaptable and Flexibility: assessed

Creative Thinking: assessed

Critical Thinking: assessed

Integrity and Work Ethics: fostered

Self-awareness and Self-reflection: assessed

Self-direction and Self-management: fostered


Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). Students who do not wish to change the design class must not enrol.

Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

Do we live a house?
Or do we house a life?
How. Do. We. Live.
Do we know HOW we live? Do we know enough about HOW we live? HOW do things around us shape the way we live? HOW do we live the things around us? WHAT are the conditions around us? WHAT makes our habits? HOW do habits change conditions?
Objective
With sets of questions, we will question
HOW TO house a life?
HOW TO cook?
HOW TO bath?
HOW TO rest?
HOW TO move?
HOW TO eat?
HOW TO plant?
HOW TO clean?
Combined with
WHAT IS
WHAT IS wood?
WHAT IS steel?
WHAT IS stone?
WHAT IS ceramic?
WHAT IS glass?
WHAT IS earth?
WHAT IS concrete?
Lined out with
WHERE IS
WHERE IS the window?
WHERE IS the stool?
WHERE IS the tree?
WHERE IS the stove?
WHERE IS the sink?
WHERE IS the lamp?
WHERE IS the door?
And never without
WHAT ABOUT
WHAT ABOUT the norm and the normative?
WHAT ABOUT the size and the scale?
WHAT ABOUT the place and the space?
WHAT ABOUT the individual and the common?
WHAT ABOUT the culture and the society?
WHAT ABOUT the weather and the atmosphere?
WHAT ABOUT the speed and the urge?
These sets of questions will guide us through the semester and form SETTINGS, SCENOGRAPHIES and SEQUENCES.
Is the way we cook defining the space or is our space changing the way we cook? Is taking a bath a matter of physical cleaning or might it also be a matter mental health? Do we sleep to rest or is the bedroom also a place to read, to play, to meet? Can space be more than circulation? What do you store, where do you hide? What is an office at home? What is work at all?

Content
0 + 3 + 13
This studio will be organized in 0 + 3 + 13 movements.
Movement 0, 1, 2 and 3 will last 3 weeks. Movement 13 will last 1 week.
During Movement 0, students will question, travel, draw, and collect from the activities of Universum Carousel Journey.
Movements 1, 2 and 3, students will work in groups of 3. These 3 students become a practice. The practice will be assigned a set of 2x HOW TO and 1x WHILST, that they will freely combine with 1x WHAT IS, 1x WHERE IS and 1x WHAT ABOUT. They will work in the form of settings, scenographies and sequences for 3 weeks.
In the next movement group members and assigned sets of questions change again. Each movement will be another group constellation of students. We study 3 times a combination of questions. All together we will by that collect an endless series of configurations of topics.
The Movement 13, will be an individual movement of questioning, connecting M0, M1, M2 and M3 all together into sets of questions that will be presented in the last week as a ground for a collective discussion.
Literature

Momoyo Kaijima:

Jan De Vylder:
Free to consult / not limited
- BRAVOURE SCARCITY BEAUTY – ISBN 97890821122572
- UNLESS EVER PEOPLE – ISBN 9789499567079
- GALLERY MAGAZINE N° I – ISBN 9789493146495

Emanuel Christ and Christoph Gantenbein:

Roger Boltshauser:
- Tschanz, Martin (2021): Roger Boltshauser, Monografie, Triest Verlag, Zürich.
- Boltshauser, Roger; Vellion, Cyril; Maillard, Nadja (2020): Pain - Stampflehm – Tradition und Potenzial, Triest Verlag, Zürich.
- Höniger, Christian; Menti, Urs-Peter, et al. (2009): Das Klima als Entwurfsfaktor, Quart Verlag, Luzern.

Prerequisites / notice

Lecture "Construction III":

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Project Management assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Negotiation assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Architectural Design (from 5. Semester on)

Number | Title | Type | ECTS | Hours | Lecturers
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Abstract

RETHINKING LANDSCAPE STRUCTURES
The semester explores new ways of dealing with infrastructure projects and exemplary climate adaptations of the Swiss cultural landscape.

Objective

DESIGNING LANDSCAPES AND PROCESSES
The primary goal of the studio is to project landscapes. This entails the constant oscillation between territorial relationships and local actions - between landscape space and place.

THINKING IN SYSTEMS
Due to the dynamics of their constituent elements such as soil, water and vegetation, landscapes change their dimensions and character with cycles and time. Designing landscape consequently means thinking in and designing systems and processes.

DEVELOPMENT OF A LANDSCAPE VOCABULARY
'Reading' a landscape, its space-defining elements – like water, topography and vegetation – and the processes and forces that shape them is as much a focus of teaching as designing. Thus, an intensive examination of our understanding of landscape and our relationship to nature goes hand-in-hand with the semester.

METHOD TO DESIGN FROM AND WITH PROCESSES
Because of the complexity of territory and task, the iterative design method is followed, oscillating between designing and analyzing, and between large and small scales. Developing an attitude, crystallizing the specific themes, and choosing the appropriate design tools are as much a part of the work process as designing the transformation processes.

Content

PROTOTYPICAL CASE STUDIES ON THE CLIMATE ADAPTATION OF THE SWISS LANDSCAPE
Based on specific issues such as landslide risks or planned tunnel projects, new innovative ways of dealing with natural events and infrastructure projects are designed - always in search of multi-layered added value for people, flora and fauna.

Parallel to the landscape design, the students get to know landscape architecture as one of the instruments with which today's questions can be answered. Because these increasingly demand different answers - systemic thinking, designing processes, accepting change and a differentiated landscape vocabulary are prerequisites for this.

Prerequisites / notice

Integrated Discipline: Landscape and Urban Studies (LUS)
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**Prerequisites / notice**
- Group work only
- Introduction:
- Intermediate crits:
- Final crits:
- Extra costs: Approx. CHF xxx.-- per student (estimated costs, without possible seminar week costs)

**Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.**


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- Group work only.
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**Competencies**
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- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Method-specific Competencies
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Group work only.

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### Extra costs:
Approx. CHF xxx per student.

### Project grading at semester end
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This is the ultimate deadline to unsubscribe or enroll for the studio.

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**Architectural Design V-IX: Topic (E. Mosayebi)**

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Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

### Prerequisites / notice

Building Construction (BUK) as an integrated discipline is included in this course.

### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
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**Social Competencies**
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**Architectural Design V-IX: Topic (A. Brandlhuber)**

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Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

### Prerequisites / notice

Group work only.

### Competencies

**Subject-specific Competencies**
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**Method-specific Competencies**
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### Competencies

#### Subject-specific Competencies
- Concepts and Theories
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**052-1115-24L Architectural Design V-IX: Topic (T. Emerson)**

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**052-1123-24L Architectural Design V-IX: The End of... (M. Issoufou)**

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**W 14 credits 16U F. Persyn**

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### Prerequisites / notice

- **Architectural Design V-IX: Topic (M. Conen)**
  - Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).
  - Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

- **Architectural Design V-IX: Topic (GD C. Baumann)**
  - Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).
  - Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

- **Architectural Design V - A New Museum (A. Caruso)**
  - Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).
  - Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.
Abstract
To be specified.

Objective
Qualification to control the design process increasingly independent and with sole responsibility and to find to an individual design methodology and attitude.

Content
To be specified.

Prerequisites / notice
To be specified.

Competencies

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: assessed

- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: fostered
  - Leadership and Responsibility: fostered
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: assessed
  - Negotiation: fostered

- **Personal Competencies**
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: fostered

**052-1145-24L Architectural Design V-IX: Voluptas S2E5 – Pathfinder W (Charbonnet/Heiz)**

*Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).*

Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
"Italian may be "such children" but their tar-babies are not physical pain or coldness; they want an absence of history, they want to start fresh. When they designed those big palaces in Rome they must have known all along about hope and death, but they were so graceful they made it look easy."

Objective
**METHODOLOGY**
1. Conduct a survey based on the objective observation of Rome; Driven by the choice of an Agent, map out a singular path within the city; Consider the subjectivity of experience and extrapolate multiple storylines.
2. Develop a project addressing a specific problematic: formulate a critical comment onto a contemporary condition; Intensify the experience to reveal further potentials.
3. Elaborate an argumentative discourse, supported by a curated selection of multidisciplinary sources.

**INCENTIVES**
Drafting & Mounting
Conceptual & Critical Thinking
Argumentation & Rhetoric
Narration & Storytelling
Scenography & Atmosphere
Expression & Composition

**SKILLS**
Researching Contemporary Concepts & Curating multidisciplinary Sources; Articulating a discursive Argument; Mastering Visual Literacy & Storytelling, Image Mounting & Composing, Architectural Drafting & Projecting.

Content
**PATHFINDER 3** is dedicated to the timeless city of Rome: its intricate history, morphology, mythology… all canonical spatial parameters as suggested by Lefebvre: political, sociological, anthropological, economical, temporal."

Our interest will focus both on the banal and the sublime, on habits, routines, and calendar rites as well as on individual and social rhythms setting the pace for society. As the ordinary interweaves thousands of beats, repetitive tunes and syncopated breaks, there can be no territoriality without its temporalities, may it be that of urbanisation, of experience, or of dreams.

The critical consideration of these paragons, further endowed with the lure of fiction, shall initiate alternate (hi)stories and cityscapes.

The design studio will be carried out in collaboration with the Faculty of Game Design of the Zurich University of the Arts (ZHdK). Together we will draft, mount, design, discuss, play… confront our perspectives onto contemporaneity and ultimately imagine audacious yet playful architectural and territorial fictions.

A series of lectures by experts from a variety of fields will enrich our investigations.

*see: Lefebvre, Henri. The Production of Space (1974)
—. Rhythmanalysis: Space, Time and Everyday Life (1992)

Lecture notes
Semester Reader will be made available as a download for registered participants.
Extended bibliography and further references will be made available as a download for registered participants.

Introduction: SEPT. 19TH
Mid-Term Reviews: OCT. 17th
Final Reviews: DEC. 19th-20th

Group Work only
Main Teaching Language: EN
LV-No. 052-1145-23U
Reader CHF 30 + Prints 50 CHF

For more information, please contact: dedardel@arch.ethz.ch

**Competencies**

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**Abstract**
The semester will focus on space as the language of architecture. Real-life constraints, requirements and disciplines will found the basis for the research in the form of fast-pace design exercise.

**Objective**
folgt

**Content**
folgt

**Prerequisites / notice**
Individual and group work
### Competencies

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### Prerequisites / notice

For 052-1105-24L Architectural Design V-IX: Topic (J.De Vylder)
- Individual and group work, including 5 or more weeks of group work.

### Abstract

To follow

### Objective

To follow

### Content

To follow

### Prerequisites / notice

CHF xx.-- per student (estimated costs, without possible seminar week costs)
Each student will receive a printed reader, containing the basic information about the course, such as schedule, syllabus and other important information, as well as examples and references for the design task, and readings to support the theoretical framework of the course.

Lecture notes
Abstract: This studio works on the idea that a substantial understanding of today's technology (internet of things, big data, machine intelligence ...) changes the perspective to architectural theory and will result in different architectural designs and building constructions.

Objective:
1) Identification and understanding of the challenges of today's technologies; 
2) techniques of working within the plenty of the internet; 
3) a methodology to design digital architectures; 
4) understanding of the shift from hard building construction to soft building applications, and 
5) an understanding of the importance of becoming a literate digital persona in order to be an architect today.

Content:
METEORA #09 will use artificial intelligence to write a text to explicate a precise position in today's world, to create a spectrum of images to reflect this world and design an architectural artefact which brings things into adequate proportions.
We are used to designing architecture from a supposedly objective perspective. With immersive technologies, we overcome this distance, expand our perception and immerse ourselves directly in the space to be designed. In doing so, we develop an altered understanding of space by digitally designing architecture and its construction while simultaneously moving within it.

The possibility to present the designs in the Immersive Design Lab using a room-filling projection and to immerse with VR goggles requires new forms of presentation, which we will explore together.

- We learn how to develop and explore our projects with virtual reality
- We learn to computationally design with the parametric tool Grasshopper in Rhino
- We present our projects interactively in the Immersive Design Lab

Prerequisites / notice

The official language in our studio is German. Table critiques can also take place in English. Lectures and project meetings can also be held in English depending on our guests.

We do not presume any prior knowledge of Rhinoceros or Grasshopper. We will introduce the necessary methods and will rehearse them together.

Individual and group work, including 5 or more weeks of group work.

Introduction: Tuesday, Sept. 17th 2024, Immersive Design Lab (HIT F 22)
Concept discussion: Wednesday, Oct. 16th 2024
Intermediate discussion: Wednesday, Nov. 22nd 2024
Presentation discussion: Wednesday, Dec. 4th 2024
Final crits:

CHF 100.-- per student (estimated costs, excluding possible seminar week costs)

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Architectural Design V-IX: Topic (A. Puigjaner)

The Architecture and Care design studio will address the spaces where human reproduction takes place. Gendered constructs around reproduction have been and still are central practices to the ways we structure social realities. Architecture and space have historically contributed to promoting and perpetuating sexist social models around reproductive labour and its associated care practices.

RAISING CRITICAL ARCHITECTURAL POSITIONS

Formulating clear and precise questions, using abstract ideas to interpret information, considering diverse points of view, reaching well-reasoned conclusions, and testing alternative outcomes. Performing qualitative and quantitative architectural research and translating it into an architectural language. Gathering, assessing, recording, and comparatively evaluating relevant information and performance in order to support conclusions.

DESIGNING SOCIAL IMPACT

Designing responding to territories of care and their characteristics, including urban context and historical fabric, soil, topography, ecology, climate, economy… Using formal, organisational, social, and environmental principles and informing two- and three-dimensional design. Understanding construction systems and their coherent formalisation. Considering the environmental impact and the reuse of the design.

COMMUNICATING ARCHITECTURAL PROJECTS

Writing, performing, and speaking effectively about an architectural design, using representational media appropriate for both the profession and for a wider audience. Making clear architectural drawings and constructing props at different scales that illustrate and communicate an architectural research and design technically, experimentally, and aesthetically.
Content

In Switzerland, official data shows that nowadays the burdens of child-rearing still predominantly fall upon women, with 70 percent expressing concerns that having a child will impact on their careers. There are a myriad of reasons for the country’s declining birth rates – for instance a stronger focus on women’s careers, challenging socio-economic conditions, and the availability of contraception – and architecture is one of them: urbanisation leading to smaller living spaces and the dispersion of support networks, the scarcity of nearby public care facilities, and the lack of adequate spaces for shared forms of care beyond the domestic sphere of the nuclear family. Public relief, despite being remarkably generous in comparison to other countries, is still insufficient: fertility treatments like IVF are not covered by insurance – while three percent of children born were conceived in vitro – child care costs are only partially subsidised, etc. Unsurprisingly, people who can become pregnant are having less and less children and, if so, much later in their life. In this context, what can the role of architecture be?

In this design course, we will imagine architectures that support alternative reproduction practices at different stages, from fertility treatments to upbringing. Speculating with new programmes and institutions, we will design collective spaces that promote and visualise shared forms of reproductive care. In the present context, the division between productive and reproductive labour, the spaces it takes place in, and the bodies that carry it out, are once again being reshaped. The limits of the domestic are blurring, the home is no longer necessarily a space for care; instead, it is a transient, productive, and networked space. On the other hand, public and collective spaces can shelter former domestic activities and become spaces for care through different bodies (human and non-human), technologies, and strategies at multiple scales.

Addressing architecture from the urban to the body, the course aims to develop a comprehensive understanding of the relationship between design and reproduction in Switzerland. We will understand dependency as a positive kin, and propose programmes and spaces that support sharing reproductive labour in transversal ways. This realignment can contribute to generating new forms of balance, ones in which we stop “caring for” and start “caring with” as a form of interdependence. We will look at the body – its spaces, contexts and rituals – as a starting point for an architectural and aesthetic proposal at multiple scales. The students will be asked to design avoiding former forms of spatial oppression and exploitation and, instead, explore the paths of otherness, wildness, diversity, complexity, and the impractical. The final objective is to propose institutions providing inclusive spaces for reproductive futures based on collective kinship.

Prerequisites / notice

Only group work.

Introduction: September 19th, 10am, HIL E 70.5
Intermediate crits: October 10th, November 21st / 22nd
Final crits: December 21st / 22nd

CHF 250.– per student (estimated costs, without possible seminar week costs)

Competencies

Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed

Method-specific Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered

Abstract

Building Construction (BUK) as an integrated discipline is included in this course.

Architectural Design V-IX: Heritage-Led Teaching Project (GD A. Beer / D. Merz)

This semester, the Design Studio (14KP) is offered in conjunction with an integrated design-build seminar week in Davos (2KP) on the Schatzalp and the elective 052-0911-24L Repair: Keep in Place (2KP) as a heritage-led teaching project. To take part in the required 052-0911-24L Repair: Keep in Place you must register separately. You will be automatically enrolled for the seminar week when you join the design studio.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Architectural Design V-IX: Topic (GD G.Retsin)

Please register (www.mystudies.ethz.ch) only after the
The examination of filmic space situations and performance discloses new perceptions of architecture which will be studied on behalf of film analyses and experimental topics. During the course space-effective creative means such as editing or framing will be introduced and discussed under perceptive aspects. Mediality within spatial perception can thus be integrated into a development of cultural history and leads towards a conception which goes beyond the limits of architecture and stimulates new processes of design.

Does not take place this semester.

The ubiquity of neural nets calls on architects to explore the vectorial world they index. After introducing participants to basic concepts of coding and machine learning, this course invites them to inventively explore hidden connections among vectorized digital objects.

In the second phase, INVENTING, participants are given access to a multi-modal corpus, an inventory containing millions of digital objects pertaining to different media – scans, sounds, samples and sentences – and a series of bespoke functions in Wolfram Mathematica. Aided by machine-learning algorithms, participants will join characteristic collections of digital objects into a story a character might tell. These collections can be based on authors, inviting participants to further engage with theoretical ideas. In the third phase, STAGING, participants will focus on bringing these stories to life through a deliverable in their chosen format, accompanied by weekly tutorials.

The course deals with spatial phenomena at the interface of film and architecture. The alternating influence of these two media will be analyzed, the dispositions of perception and effect will be compared and thus will sharpen the view for a architectural way of looking at space.

The first phase of the course, CODING, offers entry points to coding literacy as well as related theoretical literature without attempting exhaustive coverage: using Wolfram Mathematica, participants will get familiar with functional programming, including importing and exporting data, organizing it into data structures, writing simple functions and encoding and decoding digital objects into and from vectors.

The course offers 2G lecture notes and an extensive list of references. Participation in the curricular activities and project submit will be assessed through weekly tutorials, final crits, intermediate crits and project grading at semester end. Final grades will be based on the list of internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Project grading at semester end is based on the list of enrolments on 30.10.2024 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 102 of 2667
### 052-0507-24L Finding a language for change

**W** 2 credits 2S M. Kupferschmid

**Abstract**
How can we use writing to approach a new architectural form that remains relevant even in times of major social challenges such as the climate crisis? During the semester, all seminar participants will work on their own texts in which they take a critical stance towards a particular building.

**Objective**
- Using text as a way of approaching questions on climate-relevant architecture.
- Development of an individual text, ongoing revision with the help of various exercises and reviews.
- Reflection on one's own role as an architect in the architectural discourse, in relation to the climate crisis and in the changing professional field.

**Content**
How do we find a new architectural form and thus a new language in a time where everything is changing rapidly – and must change? The issues of ecological sustainability in particular are causing fundamental changes in the field of architecture and in our understanding of the profession. How does writing serve us as a means of approaching an architectural language that remains relevant in this environment? In the best sense, writing forces us to take a stance.

Over the course of the semester, all students explore several buildings. Through writing, they try to find out what it contributes to finding new forms for architecture in the climate crisis. We examine what influence sustainability has on the development process and the perception of the buildings, what new architectural language they have in store for us and what processes are taking place in the background. All students write their own short text. Over the course of the semester, they continuously revise their text and reflect on what they have written with feedback from their teachers and fellow students. The focus does not lie on the finished text, but on sharpening and at the same time constantly questioning their own attitude and continuously reflecting on what they have written.

**Lecture notes**
The students will receive a reader at the beginning of the semester.

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### 052-0583-24L Archives of the Living

**W** 2 credits 4S A. Caruso, M. Conen

**Abstract**
This course intends to use different techniques of recording and research to capture a special and important time in the history of Zurich between the late 1970s and the early 1980s. The documents that each student produces will be test of how to communicate and archiving specific topics of this time.

**Objective**
- The students will engage with existing archives, but will ask new questions in order to extend the received meanings of the material
- The students will use photographic and video recordings to represent the sites that we are studying
- The students will use social scientific interview techniques

This material will be assembled into small documents that communicate specific topics from the main theme

**Content**
Zurich between the late 1970s and the early 1980s was a city where urban activism, punk and a nascent contemporary art scene came together in an explosive way. Inspired by other scenes, in say London and New York, what was special in Zurich was how intermingled the members of the different scenes were and how influential they would become for the future shape of the city. This must have something to do with the mall scale of the city and how intertwined its society is.

Independent of official policies and large capital investments, it was the ideas and the participants of these times that has given shape, for better and for worse, to contemporary Zurich. This course will begin to engage with the stories, the people, and the artefacts of that time. Drawing on the holdings of existing social archives in the city, but also engaging through photography and writing, we will begin to construct an archive of the living for Zurich.

**Competencies**

| Subject-specific Competencies | Concepts and Theories | fostered |

### 052-0527-24L BUK Re-Detailing

**W** 2 credits 2G S. Girsberger

**Abstract**
Remodeling and reuse is the order of the day. This should be learned (again). In this elective course we construct with what we find. The limited range of materials requires a creative and flexible approach to joining and connecting. In addition to practical examples and lectures, we try to develop theoretical details using reused material.

**Objective**
Questions about both application in construction and expression should be answered. Which reused materials and elements are suitable for what and how are they assembled? What new aesthetics can be created and how can they be conveyed? The aim is to prepare the young generation of architects for the constructive use of reused materials. Using theoretical exercises and practical examples, an attitude towards building with existing things and its challenges and opportunities should be developed.

**Content**
Phase 1: Inputs and lectures give students insight into the topic of circular building. Necessities, opportunities as well as challenges and limitations of the practice are discussed together. We get an overview of processes from the organization of a component platform to non-linear planning within the architectural offices

Phase 2: In experimental exercises (groups of two to three), details on a scale of 1:5/1:10 are constructed from the collected material. The focus is on the choice of materials for the specific location and on joining the individual elements. It is examined how one can react to a given situation with limited resources. Against the background of a new aesthetic, various forms of representation are also being examined.

**Prerequisites / notice**
Attending the first event is mandatory. A list will be given out in which people can sign up. The number of participants is limited to 20 students.

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Practice-oriented seminar on the topic of analog & artistic photography

Instructed by Nicolas Rolle, the seminar serves as an introduction to analog experimentation in the creative process of artistic practice. By analyzing the motifs and ways of thinking of photographers, the aim is to develop a basic approach to the medium of photography and to expand practical work in the darkroom through theoretical questions about the medium.

Theoretical and practical introductions form the core of the targeted exploration of the photographic apparatus. Students are encouraged to gather their own experiences in analog experiments and to explore the urban space and their surroundings with the camera. With an artistic work developed over the semester, the expanded concept of photography will be sharpened and brought to an individual expression.

Lecturer approval required for all students. Please send a letter of motivation (max. 300 words) to rolle@arch.ethz.ch by 05.09.2024. The number of participants is limited to 20. The course will be held in German in the Fall Semester 2024.

Participants pay CHF 25.00 for the materials required in the course.

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Understanding Light

The seminar explores light from the perspectives of Physics and Art, opening up new dimensions for collaboration across disciplines by tackling questions such as: What is the origin and nature of light? How does it travel through space and time? How can it be made productive in an artistic sense and what, in turn, can artistic methodologies contribute to experimenting and thinking about light?

In this course, we will set a performative frame for experimentation and exploration. Coupled with experiments in the Dep. of Physics, students will be introduced to concepts such as the origin of light and color, and the interpretation of the optical world that surrounds us to understand what actually gives rise to the effects we see everyday—from butterfly wings and autumn colors to the appearance of buildings and cities. In addition, we will perform practical experiments with basic optical components like lenses, mirrors, and prisms, in order to understand how they can be used to capture images. Inputs by guest lecturers (e.g. on light in photography, anthropology or urban landscapes) are planned. Students will be asked to present related topics.

At the end of the semester, the artistic experiments will be presented.

Max. number of participants: 15

Please send a short motivation letter (max. 300 words) to artinspaceandtime@arch.ethz.ch by 05 September 2024.

Unveiling Habitats

How can architects integrate the topic of cohabitation and biodiversity into the design process? As an interdisciplinaries discipline, architecture plays a key role in promoting biodiversity in urban areas. In this seminar, promising leverages and fields of action will be explored and discussed in order to create ecologically rich and networked living spaces of high-quality.

In this context: how can integrative construction projects of the future be designed with a high ecological quality and a high quality of life - both for humans and other living beings? In this seminar, we will look at the notions, issues and actors involved in questions of biodiversity in the urban area of the city of Zurich from an architectural perspective. Theory and practice in the field of architecture and biodiversity will be linked through a variety of guest contributions from experts and on the basis of a case study and several field trips. The individual research and findings are summarized in the form of a visual project documentation and will be presented at a final event.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 104 of 2667
Analytical Competencies fostered

Presentations of the lecturer and guests will be made available.

Creative Thinking

There is a sense of new beginnings in architecture. Over the past two decades, efforts in sustainable construction have primarily focused with special focus upon the dynamic changes in this context and the related planning and building reactions to them. The objective is that the students engage in a debate of a differentiated functional planning as a basis for complex buildings which are to be successful functionally, operationally and in design. On the basis of a given scope of themes the students carry out research aiming for possible improvements for example in health facility planning. The scope of subjects is announced at the beginning of each semester.

Complex buildings such as health care buildings are subject to constant change. In a new hospital building 60% of the diagnostic and treatment areas are subject to building changes within the first 10 years of operation. Architecture has to develop concepts which accommodate this level of dynamics into the building structure in a better way. In the coming years this need for adaptability is going to be challenges even further by the even more reducing health care resources. The paper should discuss in this context a specific question in detail by analysing problems and developing and discussing potential planning solutions.

Lecture notes

Presentations of the lecturer and guests will be made available.

Re-Imagine: architectures of transformation

The shift from ‘Ersatzneubau’ as the status quo to an intelligent approach to our existing building stock has just begun. This transition demands new roles, new knowledge, and new ways of action. The course examines, through lectures and discussions with guests, the fields of action that open up for architects to actively shape a changing building culture.

The objective is to develop an awareness of the field of action of one’s own profession to help shape a sustainable building culture.

- Develop an awareness of the field of action of one’s own profession to help shape a sustainable building culture
- Understand and analyze complex and multifaceted mechanisms in the construction process, especially in the transformation processes of existing buildings
- Investigate and discuss relevant case studies, practices, and processes
- Question common practices and formulate alternative approaches

Content

There is a sense of new beginnings in architecture. Over the past two decades, efforts in sustainable construction have primarily focused on (replacement) new buildings that consume as little energy as possible in operation. Recently, the issue of embodied energy has gained more attention: in Switzerland, there is an increasing willingness to preserve not only monuments but also “everyday” buildings from demolition and to redesign them for continued use and a new life cycle. Although the practice of replacement construction still constitutes a large part of overall construction activity, a path is slowly opening towards a building culture that seeks the ongoing redesign of existing buildings instead of the tabula rasa and “clean solutions” of past decades.

This shift from a demolition culture to a transformation culture requires a new set of skills from architects. The times of standard solutions and pre-drawn construction detail catalogs are over. Transformation projects require imagination, technical skill, and a profound understanding of our building stock. We will explore the changing role of architects in this new building culture through discussions with local experts and pioneers who have demonstrated exemplary approaches in their practice and made significant contributions to the transformation. Each week, we will examine a specific step in the transformation process of a building, from strategic planning to construction. This will provide a detailed understanding of the tools and competencies that practicing architects need to learn, the contributions we can make as individuals to the transformation, and the opportunities a changing building culture can offer us.

Each session will include an introduction to the topic with practical examples, followed by guest presentations sharing their experiences, expertise, and case studies. The inputs will be discussed in plenary at the end of each lesson.
Fusions of digital-analog relationships have accompanied us since the very beginning of the digitalization era. The rapidly growing impact of digital technologies on our life necessitates constant adaptation. The course introduces the term "Hybrid Reality," which represents the coexistence of physical and digital spaces. Using state-of-the-art VR technologies, the methodology focuses on immersive, real-time, 1:1 scale space creation, exploring corporeal design, and reinventing conventional methods. Students will learn to digitize physical spaces, create hybrid reality environments, and design interactive exhibitions.

The course "360 – Reality to Virtuality" is interconnected with "3D Scanning and Freeform Modeling".

You must register for both courses: "360 – Reality to Virtuality" and "3D-Modeling" (2x 2 ETCS). Classroom teaching as 4h block + self-teaching and research at home.

Max. number of participants 15 students.

A 200 CHF deposit will be charged for the VR Headset. It will be refunded upon the return of the headset on the last day of the course.

If you already have an Oculus Quest 2, you do not need to pay any deposit and can work on your own device.

Please send a short application email (max 150 words) to Adam Kiryk: kiryk@arch.ethz.ch

Enrolment in agreement with the lecturer only

Classroom teaching as 4h block + self-teaching and research at home.

You must register for both courses: "360 – Reality to Virtuality" and "3D-Modeling" (2x 2 ETCS).

The course "360 – Reality to Virtuality" is interconnected with "3D Scanning and Freeform Modeling".

Students formulate a precise research question for the course that they investigate through tests and a model of a built architectural project during the semester.

The individual tests, material samples, and fabrication techniques are continuously questioned to make specific decisions related to the research goals. The students will derive the model type, scale, context, material, and level of detail from their findings - this will inform the further development of the research question.

The model resulting from this process, the accompanying tests, and the project documentation provide insight into possible answers to the research question and allow the students to check the validity of their assumptions to inform their studies.

We expect you to have sound knowledge of building 3d models and creating plans. Our class supports Rhino3D, but you are free to use modeling tools you already know.

In addition to the course taking place in person (3h), an independent processing time of 5-6h/week is needed to complete your project successfully.

The students will design models as tools for understanding complex questions by investigating an existing architectural project.

The students will test materials, techniques, and construction principles for model-building by completing hands-on activities.

The students will test and challenge model-building conventions by building examples.

The students will review their work by creating annotated images and writing texts as part of their course documentation.

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The students will test and challenge model-building conventions by building examples.

The students will review their work by creating annotated images and writing texts as part of their course documentation.
The number of participants is unlimited. The course takes place on Thursdays from 12:00 p.m. to 2:00 p.m. in the ONA Hall E7. The class will be held in German.

If a credit is sought, the following is required to pass the elective:

- The definitive registration takes place after attending the introductory event.
- The number of participants is unlimited. The course takes place on Thursdays from 12:00 p.m. to 2:00 p.m. in the ONA Hall E7. The class will be held in German.

If a credit is sought, the following is required to pass the elective:

- The drawings must be uploaded to the drawing blog on the respective practice day. Attendance and submission is required for at least 8 practice days. The submissions on the blog must contain the category of your name and that of the respective lecture title. You will receive further information on this at the beginning of the elective course.

**052-0549-24L**  
**Hybrid Modeling: 3D-Printing for the Architectural Design**  
**W** 2 credits  
**J. Benhamu Esayag**

**Abstract**  
The HYTAC Elective Course offers the opportunity to explore alternative ways to approach Point Cloud and 3D Printing in a simple way. The students will learn the basic principles and workflows behind photogrammetry, 3d-modeling and 3D-printing, to produce digital and physical (3d-printed) models.

**Objective**  
By the end of this course, the students will be capable of:

- a) creating and processing point-cloud-generated models in Blender
- b) producing 3D-printed models in architectural scale
- c) using the above digital tools to advance their personal design workflows.

**Content**  
The goal of the course is to introduce digital technologies and facilitate common architectural workflows by skipping the time-consuming processes of 3D modeling.

The course includes:

- Introduction to photogrammetry and 3D printing through lectures and tutorials.
- Generation of a digital twin of the selected site through photogrammetry and production of a physical model (3D printed)
- Use of Blender. Basic skills can be acquired during the course.

In case of questions regarding the course, please visit our website: https://hytac.arch.ethz.ch/courses/elective-2/ or contact us directly via email (hytac@arch.ethz.ch).

**Literature**  
www.3djony.com

**Prerequisites / notice**  
Basic Knowledge of 3D printing technology is not required.

**Competencies**  
- Subject-specific Competencies: Concepts and Theories fostered
- Subject-specific Competencies: Techniques and Technologies fostered
- Method-specific Competencies: Analytical Competencies fostered
- Method-specific Competencies: Decision-making fostered
- Method-specific Competencies: Media and Digital Technologies fostered
- Method-specific Competencies: Problem-solving fostered
- Social Competencies: Communication fostered
- Social Competencies: Cooperation and Teamwork fostered
- Social Competencies: Sensitivity to Diversity fostered
- Personal Competencies: Adaptability and Flexibility fostered
- Personal Competencies: Critical Thinking fostered
- Personal Competencies: Integrity and Work Ethics fostered
- Personal Competencies: Self-awareness and Self-reflection fostered

**052-0533-24L**  
**New constructive places of contemporary timber construction II**  
**W** 2 credits  
**I. von Meiss-Leuthold, D. Mettler, D. Studer**

**Abstract**  
The elective subject "New focal points of construction" investigates on the basis of contemporary architecture the complex interaction of construction elements. The comparative analysis of built constructions serves as a basis for further development of future constructions. This semester will focus on building with new timber construction.

**Objective**  
The target of the course is the understanding of the impacts of material, technology and construction to the architectural education of constructive points. The focus lies on the present state of technology and the current challenge of building. The conjunction to current constructive methods and basic conditions enables a critical evaluation of the constructive Status Quo within the contemporary producing architecture as well as a perspective to new constructive education.

**Content**  
Course:
1. Introduction of current level of technique
2. Colloquium with guests of producing and processing companies.
3. Visit of construction site and factory

Excercise:
- Analysis and presentation in group of two of a building.

The definitive registration takes place after attending the introductory event.

**Competencies**  
- Subject-specific Competencies: Concepts and Theories fostered
- Subject-specific Competencies: Analytical Competencies fostered
- Subject-specific Competencies: Decision-making fostered
- Subject-specific Competencies: Media and Digital Technologies fostered
- Social Competencies: Cooperation and Teamwork fostered
- Personal Competencies: Critical Thinking fostered

**052-0569-24L**  
**Lecture Series Design and Architecture (Ringvorlesung): Practice what we teach?**  
**W** 2 credits  
**A. Fonteyne**

**Abstract**  
Specialists give lectures on current architecture-specific topics.

**Objective**  
Obtaining knowledge from architectural practice after 2020.

**Content**  
Specialists give lectures on current architecture-specific topics.

Lecturers are listed in due time.
### Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptable and Flexible
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Prerequisites / notice
For more information, please contact: veiga@arch.ethz.ch

### Prerequisites
- 052-0557-24L
- 052-0561-24L
- 063-0561-24L

### Literature
- Required readings and recommended screenings will be made available as a download for registered participants.

### Competencies
- Self-awareness and Self-reflection
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### Objective
Understand the complex relationships between material, detail and built artifact. New artistic methods are designed, analyzed and applied from a deeper understanding of innovative building materials.

### Abstract
This course will invite students to take the stance of a spoilsport in relation to established typological norms and rules. By doing so, the edges of knowledge on typological definition should be expanded in unforeseen ways, allowing new interpretations of existing architectural stapples and the formulation of new design approaches to long-standing norms and rules. Withdraw from the current, play a different game.

### Excerpt of Johann Huizinga’s “Homo Ludens – A Study of The Play Element in Culture”, 1955
Excerpt of Johann Huizinga’s “Homo Ludens – A Study of The Play Element in Culture”, 1955

### Content
- The edges of knowledge on typological definition should be expanded in unforeseen ways, allowing new interpretations of existing architectural stapples and the formulation of new design approaches to long-standing norms and rules. Withdraw from the current, play a different game.
- By doing so, the course will invite students to take the stance of a spoilsport in relation to established typological norms and rules. This is because the spoilsport shatters the play-world itself. By withdrawing from the game he reveals the relativity and fragility of the play-world in which he had temporarily shut himself with others. He robs play of its illusion—a pregnant word which means literally “in-play” (from inlusio, illudere or inludere)\*

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*Excerpt of Johann Huizinga’s “Homo Ludens – A Study of The Play Element in Culture”, 1955*
The course "360 – Reality to Virtuality" is interconnected with "3D Scanning and Freeform Modeling". You must register for both courses: "360 – Reality to Virtuality" and "3D-Modeling" (2x 2 ETCS). Classroom teaching as 4h block + self-teaching and research at home.

Max. number of participants 15 students.

A 200 CHF deposit will be charged for the VR Headset. It will be refunded upon the return of the headset on the last day of the course.

For students from the 3rd semester

Upon completion of the course, students will have:
1. acquired a general knowledge of the role of architecture and urban planning in the historical context of development aid, the main actors involved, and strategies adopted
2. acquired an in-depth knowledge on the specific housing paradigm of 'sites-and-services'
3. developed a critical attitude in engaging with the history of postcolonial urban design
4. developed a theoretical understanding of the act of inhabitation as central to architecture and its history
5. developed a reflective attitude on the modes of writing architectural history and the role of inhabitation in it
6. strengthened their analytical skills by engaging in text- and project-based discussions, their collaborative skills through team-based project analyses, and their communication skills through presenting the outcomes of their work to their peers.

In our seminar series ‘The City Lived’ we focus on the history of urban design, with a particular emphasis on the lived experiences in the city. This semester’s seminar will focus on ‘sites-and-services’, an important housing paradigm that was mobilized in the context of development aid to provide cost-efficient housing for the global poor.

This housing strategy consisted of providing ‘sites’ – plots of land to construct dwellings on – in combination with a set of ‘services’, ranging from infrastructural features, such as sewerage and waste disposal, to market-based interventions that aimed to make cheap building material more easily accessible, or financial loan schemes that offered inhabitants the means to invest in their homes. It often operated on a large scale, and targeted thousands of households in a single project. For several decades from the 1970s, it was heavily endorsed by major actors such as the World Bank and the United Nations as a cost-efficient way to meet the most basic housing needs of a high number of people, whilst simultaneously offering authorities the means to direct the enormous growth of spontaneous settlements in the urban peripheries as part of their broader urban development plans. As such, these sites-and-services schemes have left a major imprint on many cities in the Global South. Despite this impact, however, their histories are not well documented.

Whereas sites-and-services were promoted as a cost-efficient solution to the housing problem of the global urban poor, the housing paradigm attracted severe criticism from its inception. One line of critique considered such programs as formalizing the state’s disinvestment in its poorest citizens, symptomatic of neoliberal policies that erode structures of state support, while another line of critique considered them as instruments of a globalizing debt economy, incorporating the global poor in an expanding, profit-oriented capitalist market.

Beyond its praise and criticism, in this seminar we study sites-and-services projects in the first place as material artefacts: as man- and woman-made built environments that have shaped the lives of thousands of people, whose history for that very reason deserves to be studied.

In doing so, we will discuss two broader themes. On the one hand, sites-and-services projects allow us to problematize the notion of housing expertise and how it was mobilized in the Global South. Therefore, we will discuss them against the background of housing policy in the Global South more generally. Which housing paradigms were relied upon in the context of the Global South? And what were the logics underlying them? On the other hand, since these were essentially unfinished projects that relied on their future inhabitants to complete their dwellings, in this seminar we will not only intend to dig up the histories of such projects, but also to discuss what we can learn from the histories of such atypical housing projects. Inhabitants have drastically expanded and transformed the initial minimal design to often unrecognizable degrees according to their needs and resources, and many sites are now integrated into wider urban patterns. How do we write the history of ‘unfinished’ projects? How do we acknowledge the act of appropriation and inhabitation as an integral part of such projects?

This course is based on weekly two-hour seminars, in combination with a case study analysis in small groups. After introducing the main context, the seminars are structured around the themes of ‘housing expertise’ and ‘lived architecture’, and gradually shift from tutor-led input sessions to student-led text discussions and project presentations. After the first class, students will be asked to form balanced groups of 3 students to work on one sites-and-services project (from a pre-selected list) over the course of the semester. The semester-long case study analysis will culminate in a final presentation and an exhibition entry that will be included in a collaborative online exhibition. Three main feedback opportunities are provided within the contact hours: short ‘Flash Presentations’ during Seminar 3, ‘Mid-Term Presentations’ during Seminar 6, and a final in-class workshop focused on students’ writing and exhibition entry during Seminar 9.

Students are expected to actively attend and participate in each session. During the input phase, each week students are required to read 1–3 texts (‘Compulsory Reading’) and actively engage with other students and tutors on a pre-assigned digital canvas sheet (via Padlet).

An online exhibition based on earlier student work can be consulted here: https://repository.avermaete.ethz.ch/exhibitions/sites-and-services/
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**052-0813-24L**

**History, Criticism and Theory in Architecture:**

**Architectural Ecology II: A History**

**Abstract**

In this seminar we will, on the one hand, deal with the central strategies in the context of the climate crisis and get to know them by reading theoretical key texts. On the other hand, we will analyze concrete architectural case studies from Europe and Japan on this basis and thus examine these as well as the theoretical strategies for their potentials.

**Objective**

By combining theoretical foundations and practice-based approaches, the course aims to develop a deeper understanding of theoretically grounded ecological architecture while capturing and questioning the methods of current practice from a variety of perspectives.

**Content**

Climate change confronts architecture with a series of new and complex challenges that are reflected in a specific vocabulary. Terms like sufficiency, circularity or cohabitation are shaping the debates around this crisis or are standing for possible ways out of it. At the same time, the immediate nature of the situation forces us to critically question or revise common standards in the built practice - without having established new reliabilities in advance. Instead, a wide variety of isolated, sometimes contradictory strategies are being pursued simultaneously: Replacing fossil building materials with ecological ones, striving for "less" or a "different" way of building, low-tech and high-tech approaches, simple or multi-layered constructions. Theoretical and practical perspectives seem to be little connected so far.

In this seminar we will, on the one hand, deal with the central concepts and strategies of the current debates and get to know and question them by reading key theoretical texts. On the other hand, we will analyze relevant case studies from Europe and Japan on this basis and thus examine both the theoretical strategies and the concrete projects for their potentials.

By combining theoretical foundations and practice-based approaches, we thus aim to develop a deeper understanding of an academically informed, ecological architecture, while at the same time capturing and questioning the methods of our current practice from a variety of perspectives.

**Prerequisites / notice**

As we want to ensure a constructive discussion during the Seminar, we need to limit the amount of students participating.

To this end, we kindly ask you to send us a short letter of motivation. This does not need be long (3-5 sentences should be enough), but make sure to state concisely why you would like to join us for this course.

Please send your statement to kersting@arch.ethz.ch by Monday the 18th of September (23:59). We will notify the accepted candidates by Wednesday the 20th.

**052-0817-24L**

**Theory of Architecture: Desert Modernism(s)**

**Does not take place this semester.**

**Abstract**

Worl’s major deserts—both hot and cold—have often served to search, extract, and transport the deserts’ various natural resources, such as oil and gas, as well as to design and build new cities, infrastructures, residential architecture, tourist complexes, farming systems, solar power plants, climate and aerospace research centers, chemical weapons testing complexes, nuclear weapon research centers...

**Objective**

Knowledge of architectural photography

**Content**

History, theory and practice of photography in relation to architecture

**Prerequisites / notice**

This course runs on a bi-weekly schedule in two separate groups limited to 15 students each and is taught in English.

Students will be selected on the basis of a motivation letter.

Course dates and place: see room reservation.
Special Questions in History of Art and Architecture:
Architecture in the Expanded Field

**Abstract**
This seminar will explore contemporary architecture through the lens of its ever expanding field, taking as a starting point the view that we “both do and do not know” what architecture is. Together we will discuss texts, visit workspaces and have conversations with practitioners who work at the interfaces of architecture, art and other disciplines.

**Objective**
This course aims to sharpen critical reading and thinking skills. Students should come away clearer about their position on the contemporary contours and potentials of architecture.

**Content**
Adapting our course title from Rosalind Krauss’s prominent essay on sculpture (1979) but not strictly following its argument, we will pay special attention to ways that architecture intersects with art (and other disciplines), whether through direct collaboration, cross-referencing, role-swapping, or the engagement of parallel topics or methods.

A series of conversations with internationally known practitioners who work at the interfaces of architecture, art and other disciplines will form the basis of our discussions.

In addition, we will visit relevant locations and read and discuss texts from the fields of history and theory.

**Literature**
Literature will be provided at the start of the semester. Texts will be in German and English language.

**Prerequisites / Notice**
Due to the guest talks and visits planned, individual sessions might take place at times or locations different from the regular time-table. The adapted schedule will be communicated during the first meeting.

Texts and conversations will be in German and/or English.

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PhD Teaching: Drawing Things Together: Drawings
Beyond Disegno

**Abstract**
This seminar will study the material, cultural, and social parameters that conditioned drawing practices in Europe from the 15th through 19th centuries. We will examine drawings firsthand, and compile critical perspectives to grasp the varied roles drawings performed in artistic and architectural practices as well as the production of knowledge, and the constitution of power structures.

**Objective**
The course aims to sharpen the historical awareness of the media conditions of architectural design. It does so by highlighting the practice of hand drawing in the face of today’s digital imaging devices and through a critical engagement with the material, cultural, and social conditions and implications of the allegedly neutral blank page. This exploration also involves a methodological reflection of historical research. We will delve into in-depth reading of texts from various scientific fields and disciplinary perspectives. This will require the preparation of one text per session, which will be moderated alternately by one or two assigned students. This reading component will be complemented by visits to drawing collections and study rooms, to familiarize ourselves with the historical materials. Texts and discussions will be held in German and English, requiring a sufficient command of both languages.
How can we think of utopias in the dystopian times we live in? Are all utopian visions devoid of reformist agency, as historians have assessed? What is the role of architectural history in navigating these questions? This course critically interrogates the concept of utopia in its historical and spatial dimensions, through a combination of lectures, readings, and in-class discussion.

This course departs from two influential paradigms and shifts the focus to the material, cultural, and social parameters that conditioned drawing practices in the early modern period. We will consider the act of drawing less an externalization of an individual mind than a cultural technique, just as we will consider drawings less the traces of a creative process than social objects. Drawings can be read as tacit notations of discourses and practices, as tools of collaboration and exchange, as sites of the production of knowledge as much as of institutional centralization and social power.

This entails refraining from any attempt at a systematic or conclusive history or theory of drawings in favor of gathering various theoretical observations and critical perspectives, combining thoughts, approaches, and questions from such diverse fields as art history, history of science, cultural studies, and media theory. The texts we will subject to an in-depth reading in assigned sessions, therefore, range from classical pieces of architectural history to contemporary contributions of critical theory. The reading sessions will be complemented by on-site visits to study rooms and drawing collections to enable firsthand engagement with the historic materials themselves.

Such “utopias of the rear-guard” will be the focus of our course. Bringing together archival material and secondary sources, we will explore the spatial articulation of feminist, decolonial, spiritual, and other collectivist sites of resistance. Although the gravity of this theme is heightened by the exigencies of our present, the emphasis of the class will be on pre- and early modern examples, with particular attention paid to the socio-political structures of the Enlightenment.

Students will learn how to approach primary / archival and secondary sources and will be given a curated selection of readings to support their understanding of key concepts, such as utopia, identity, colonialism, etc. They will be given the opportunity to research their own case studies, curate material, and present on it at the end of the semester in a symposium format. Most importantly, they will learn methodologies to engage with the architectural form and the built environment critically, as well as to approach early modern episodes through contemporary lenses, in a historically responsible way.

Architecture’s historical failure to breathe life into reformist, utopian dreams can feel disempowering, especially in light of current escalating ecological, political, and cultural challenges. If, however, the clean slate worlds envisioned by architectural avant-gardes have traditionally failed to materialize into a more equitable future, there is still a lot to learn from practitioners, theorists, and communities who devoted their efforts to resist disenfranchisement, and to reclaim and restore the equity of their present.

Enrollment limited due to intensive workshop format. Course intended for students from 5th semester onwards. Attendance in all sessions required.

This course departs from two complementary propositions. The first is Manfredo Tafuri’s claim that modern architectural utopias not only lack reformist agency, but are often complicit in promoting and establishing the status quo of the ruling capitalist class. The second, is Anthony Vidler’s theorization of modernity as the defensive attitude of humanity against an increasingly threatening natural, social and political environment.

The course will thus be divided into two parts: the first, devoted to the historicized study of.Validation and interpretation, and the second, devoted to the critical applications of the results. Through the process of interpretation and critique, we will seek to identify and assess the assumptions and implications of the modernist project, and to evaluate its potential for contemporary use.

Students will be expected to engage actively in class discussions and to participate fully in the development of the course’s themes and topics. They will be required to complete a series of assignments that will allow them to develop their own critical perspectives on the material presented in class.

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The subject of this seminar is the relationship between architecture and social class. Our inherited class reference determines our social architecture: how we relate to each other in a historically grown, hierarchically structured space, how we perceive the built world, how we intervene in it in a creative way and how we judge sensuality and beauty, all of this is strongly pre-structured and yet leaves nothing to be desired leeway open. We can't help what class we're born into, but we can understand, meditate—and maybe even change—the social reflexes and unconscious beliefs that arise out of this coincidence. This seminar offers a sociological, historical and aesthetic basis for this.

• On the basis of theoretical texts, a number of questions are discussed: How is the racialization of the working class manifested in the history of cultural production? How are economic discrimination and privilege in the field of the arts related to normative gender categories? How do we make the big analytic terms our own when we write about class and architecture to connect with others?

• Exercises on graphical representations of social strata. What is a spatial perspective considering the creativity of class habitus? How can we present the fragments of our perception, determined by class origin, as a whole without leveling or even condemning individual positions? How do we deal with the naturalized power of imagery's common sense when representing class issues in architecture?

• Personal engagement with autobiographical photo material regarding the manifestation of the habitual, inherited lifestyle of a certain milieu or a certain class faction - or regarding the manifestation of the break with this heritage. Approaching the answer to the question: What makes the difference - between a narcissistic and an objectified architectural view of social space?

In autumn 2024, two exhibitions take place in Zurich focusing on Switzerland and its colonial interdependencies. In the seminar, this topic will be addressed using the Graphische Sammlung ETH Zürich as an example. The students will research a selection of works from the collection, read specialized texts and discuss the jointly visited exhibitions.

Students learn about the history of the collection and work on individual works of the Graphische Sammlung ETH Zürich with a possibly critical approach. What makes the difference - between a narcissistic and an objectified architectural view of social space?

The compulsory texts will be available at the beginning of the seminar.

The seminar is limited to 20 people. There will be a waiting list.

Please note:
Several meetings will take place at Graphische Sammlung ETH Zürich in the main building or in museums in Zurich. Time for travel before and after the meetings is therefore necessary.

052-0845-24L Reflection on Exhibition and Art Practice Now. Colonial Influence? Focus on the Graphic Arts Collect

Abstract
In autumn 2024, two exhibitions take place in Zurich focusing on Switzerland and its colonial interdependencies. In the seminar, this topic will be addressed using the Graphische Sammlung ETH Zürich as an example. The students will research a selection of works from the collection, read specialized texts and discuss the jointly visited exhibitions.

Objective
Students learn about the history of the collection and work on individual works of the Graphische Sammlung ETH Zürich with a possibly critical approach. What makes the difference - between a narcissistic and an objectified architectural view of social space?

Content
It has long been known that although Switzerland itself was not a colonial power, it nevertheless has complex colonial ties. This will be the subject of two different exhibitions in Zurich in autumn 2024 and will also be the topic of a seminar focusing on a collection of ETH Zurich: Graphische Sammlung ETH Zürich. In addition to reading specialized texts and visiting the exhibitions at Landesmuseum (ikolonial – Globale Verflechtungen der Schweiz), students will familiarize themselves with various forms of presentation and ways of communicating the topic.

The compulsory texts will be available at the beginning of the seminar.

The seminar is limited to 20 people. There will be a waiting list.

Please note:
Several meetings will take place at Graphische Sammlung ETH Zürich in the main building or in museums in Zurich. Time for travel before and after the meetings is therefore necessary.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Sensitivity to Diversity assessed
Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed

052-0851-24L Exploring Internationalism: How to work for UNESCO?

Abstract
This seminar explores the different actors working for UNESCO and the role of bureaucracy and international relations in their work. We will focus on the 1970s project on "Traditional Forms of Architecture", the collaboration with the International Union of Architects on an international information network in architecture, and the 1983 Bangkok workshop on "Training of Barefoot Architects".

Objective
The goal of this seminar is to develop an understanding of how international organisations such as UNESCO work internally and how they try to act in the world. In addition to academic argumentation and writing, the seminar will provide basic skills in working with archival material and analysing printed material from the 1970s and 1980s. The final assignment will be a short academic paper on one of the three case studies.
This is not a seminar on how to get a job at UNESCO. Rather, we will explore who works for UNESCO, what they do in the field of architecture, and the role of bureaucracy and international relations in their work.

The United Nations Educational, Scientific and Cultural Organisation (UNESCO) is an international organisation that coordinates a wide range of activities related to architecture. These include the preservation of historical monuments and the establishment of a universal cultural heritage, initiatives for school construction projects, the commissioning of manuals and the implementation of training programmes.

In this seminar, we will focus on three case studies to disentangle the UNESCO apparatus.

The first section will look at the UNESCO project on “Traditional Forms of Architecture” in the 1970s, led by Wolf Tschettermann, Acting Director of UNESCO’s Human Settlements and Socio-Cultural Environment Division. Through contacts with a variety of architects and academics around the world, he collected and commissioned studies on what he called “architecture without architects”, particularly in countries where development projects threatened to transform the existing built environment. We will look at published articles, audio-visual material and documents from the UNESCO archives to understand how these studies were produced (negotiations, contracts, payment) and used (publications, exhibitions, etc.) by UNESCO.

The second part will focus on the cooperation between UNESCO and the International Union of Architects (UIA), exemplified by the joint project ARKISYST, “an international information network in architecture”. Sponsored by the Spanish government and coordinated by the architect Donald Conway, the possibility of establishing a global exchange of information on architecture and urban planning was intensively studied but never implemented. This case study allows us to question notions of international standardisation, global participation and open access.

The third section of the seminar will examine the UNESCO Workshop on “Training of Barefoot Architects” in Bangkok, 30 May–4 June 1983, which was organised by the UNESCO Regional Office for Education in Asia and the Pacific. The aim of this analysis is to explore the different perspectives of the various actors involved in this workshop, including the architect Yona Friedman. The UNESCO archives provide a valuable source of information on the criticism of the approach and attitude of the “foreign expert” by local architects.

Competencies

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063-0861-24L Integrated Discipline HS24 in the Field of History and Theory of Architecture (GTA)

Enrolling in this course is only possible on agreement with the lecturer and if you attend a design course (V-IX) at the same time.

Abstract

Works in the integrated discipline art and architectural history evolve in close connection with projects in design. Textual and creative works are possible. The length of the text or the extent of the creative project will be decided upon individually.

Interested students are asked to develop a (textual or diagrammatic) concept sketch explaining the content and the form.

Objective

We expect that students pursue their examination of the design process independently and in an original manner or that they develop a related theme from the perspective of the history of art and architecture.

The work should be part of the design process and interact with it formally and in regard to content.

Content

Weks in the integrated discipline art and architectural history evolve in close connection with projects in design. Textual and creative works are possible. The length of the text or the extent of the creative project will be decided upon individually.

Interested students are asked to develop a (textual or diagrammatic) concept sketch explaining the content and the form.

052-0823-24L History of Art and Architecture: The School of (Sub)Curating

Abstract

The School of (Sub)Curating asks, discusses, plays with and ventures into the question of how to visualise art and knowledge in space. It teaches you a history of curating and challenges you to become active in figuring out spatial forms of presentation for artworks, books, magazines, films, sounds and more. With guest artists, curators and researchers.

Objective

The School of (Sub)Curating teaches you about curating both historically and practically. It increases the knowledge of and sensitivity towards space in relation to presentation and exhibition and their underlying histories. It asks students to take on an active role in further expanding, assessing critically and playing experimentally with these histories.

Students will learn to take into account different modes of presentation, to think about the translation of images, texts and other artefacts into space as well as addressing an audience through display, writing, discourse and invention.

Each student, or group of students, will realise a small exhibition/presentation of a project, which will be on view at Kunsthalle Zürich in autumn/winter 2024.

Content

The School of (Sub)Curating asks how to translate art and artefacts into space. How to install documents about an exhibition? Or a book? Or a digital magazine? How to contextualise an early platform for digital arts? How to introduce historic design for therapeutic toys? To stage children’s books? To show a magazine stored on a USB stick? To translate travel books into space? Or films about exhibitions? What about presenting sound? Or a radio station? The collaborative seminar starts with introducing ways of curating, formats and projects.

Then over to you: you take on one project, visualise it, install it and present it during an opening. It will be part of the exhibition AAA stage children’s books? To show a magazine stored on a USB stick? To translate travel books into space? Or films about exhibitions? What about presenting sound? Or a radio station? The collaborative seminar starts with introducing ways of curating, formats and projects.

Then over to you: you take on one project, visualise it, install it and present it during an opening. It will be part of the exhibition AAA

Literature

https://ursprung.arch.ethz.ch/lehrveranstaltungen


"Why look at animals?" is the title of an article from 1980 by British writer and art critic John Berger. In this fundamental text Berger looks at the question of cohabitation of humans and 'non human animals' and "human animals). Examples include structures which have been built with often high architectonic ambitions for certain species of animals, like stables, riding houses, pigeon towers, zoos and different typologies of agricultural buildings from different regions and epochs. (Examples: Riding house of William Cavendish in Bolsover Castle 1660ies, Hameau de la Reine, toy farm for Marie Antoinette, Versailles, 1783-1788; Pigeon towers in Iran; Hugo Häring, Gut Garkau, 1922; next phase for the expansion of Zoo Zürich, Tessiner Houses, etc.)

The second module focusses on the city as a shared space for humans and animals. Until the beginning of the 20th century, masses of animals were kept within the confines of big cities. It came with its own challenges, so called "cultural followers" and "pests", which made a strong impact on building, zoning, and developing the city. Zoonoses were and still are a serious threat today, influencing urban planning. (Examples: Johann Bernhard Fischer von Erlach, Imperial riding school and stables in Vienna; Animals in "Georgian" London; Union Stock Yards, Chicago, ab 1865; Pest and rats, Urban Foxes, Racoons in Berlin et. al.)

The final module focusses on recent discourses of human-animal-relations in philosophy, biology and literary studies, leading to the new interdisciplinary field of "Animal Studies". The focal point is the question, which roles and which spaces were and are given or denied to animals in our built environment. In this seminar, students will read texts from different academic fields contributing to the new research area of the so called "Animal studies" – biology, sociology, history, philosophy, ecology, art history, literary studies – and apply this knowledge on architecture. Thereby buildings and cities are not seen as a mere stage for interactions between humans and animals but as active contributors facilitating or hindering these encounters.

Throughout the course, students will develop a high degree of independent thinking, the ability to read texts critically and apply the results on historic and contemporary examples, be it the built environment, a text or an art project. Via individual presentations students learn to process complex content verbally and visually and answer questions. This schools several important skills like abstraction of content, conveyance of content, visualization, reaction to unforeseen questions et. al. With the joint close reading students will further exercise the analytical skills whereas the final discussion will train the discursive skills and show how to synthesize differing positions.

The program comprises following elements:

- short students presentations 15-20 minutes
- several mini lectures by the lecturer
- impulse lectures by guest
- joint close reading of key texts
- joint analysis of projects
- excursion Hönggerberg
- final discussion
- submission of power point presentation (The lecturer will comment individually on the submission of the power point presentation.)

The seminar is organized in three modules:

I Building for animals

The first module will focus on buildings (or environments) designed to accommodate animals (and often to accommodate the proximity of "non human animals" and "human animals"). Examples include structures which have been built with often high architectonic ambitions for certain species of animals, like stables, riding houses, pigeon towers, zoos and different typologies of agricultural buildings from different regions and epochs. (Examples: Riding house of William Cavendish in Bolsover Castle 1660ies, Hameau de la Reine, toy farm for Marie Antoinette, Versailles, 1783-1788; Pigeon towers in Iran; Hugo Häring, Gut Garkau, 1922; next phase for the expansion of Zoo Zürich, Tessiner Houses, etc.)

II Animal city

The second module focusses on the city as a shared space for humans and animals. Until the beginning of the 20th century, masses of animals were kept within the confines of big cities. It came with its own challenges, so called "cultural followers" and "pests", which made a strong impact on building, zoning, and developing the city. Zoonoses were and still are a serious threat today, influencing urban planning. (Examples: Johann Bernhard Fischer von Erlach, Imperial riding school and stables in Vienna; Animals in "Georgian" London; Union Stock Yards, Chicago, ab 1865; Pest and rats, Urban Foxes, Racoons in Berlin et. al.)

III Architectural and animal theories

The final module focusses on recent discourses of human-animal-relations in philosophy, biology and literary studies, leading to the new field of more or less radical "animal studies" or "human-non human animal studies" emerging within the last two decades. In this part of the course the renewed focus on questions of cohabitation in a global perspective is studied through contemporary texts and art/architectural projects with a strong political message. These objects and projects are taken as a starting point for a discussion on the future role of architecture and urban planning in fostering biodiversity. (Examples: Donna Haraway, When species meet, 2007; study: Animal Aided Design, 2015; Installation: Mapping the post human city, 2021)
For centuries, advice literature has extensively examined the codes of propriety, or decorum, and ordered both the plot and the stage of performance. The seminar draws architectural history's attention to textual sources from advice literature that formulate the normative and gendered standards of interior design, decoration and homemaking. Through a critical examination of advice ranging from Ottoman adab books to Western etiquette manuals, we will examine the various regimes and expressions of gender embedded in the skin of architecture.

How do we comply, condone, distort, or resist gender roles in our manners and social conduct? And how does this performance inform our own position? We are exposed to the notion of social lives of objects. How do we comply, condone, distort, or resist gender roles in our manners and social conduct? And how does this performance inform our own position? We are exposed to the notion of social lives of objects.

Thomas Ameroth-Williams, City of Beasts, How animals shaped Georgian London, Manchester University Press, 2019
The Urbana Habitat: Tier und Mensch in Lebensgemeinschaft, Die Architekt, Nr. 2023.

Recommended reading:

Thomas Ameroth-Williams, City of Beasts, How animals shaped Georgian London, Manchester University Press, 2019
The Urbana Habitat: Tier und Mensch in Lebensgemeinschaft, Die Architekt, Nr. 2023.

Recommended reading:
The elective introduces to the subject and complexity of the urbanized landscape and teaches the critical engagement with the challenges and potentials of current tendencies in Landscape Architecture. On the basis of a concrete study area, students examine the large-scale design on a territorial scale. On the basis of cartographic analysis and field trips, students will develop concrete strategies for the urban landscape of the Città Metropolitana di Torino.

For further information see: https://www.versobooks.com/books/4089-henri-lefebvre-and-the-theory-of-the-production-of-space

The elective deals with current transformation processes of metropolitan landscapes in Europe and introduces landscape architecture design on a territorial scale. On the basis of cartographic analysis and field trips, students will develop concrete strategies for the urban landscape of the Città Metropolitana di Torino.

For further information see: https://www.versobooks.com/books/4089-henri-lefebvre-and-the-theory-of-the-production-of-space

The book will be published by Verso in November 2022, and offers an encompassing, systematic, and accessible introduction to Lefebvre’s theory of space and the urban. We will provide pre-print copies of the individual chapters to the seminar participants.

The goals of this course include:
- reading, debating and discussing a scholarly text
- acquiring new skills in reading and applying a theoretical text
- strengthening ability to read, present and debate academic texts
- getting familiar with one of the most important theories on space and the urban in social sciences

The number of participants is limited to 40-50.

Participants will be expected to engage actively in:
- reading, debating and discussing a scholarly text
- acquiring new skills in reading and applying a theoretical text
- strengthening ability to read, present and debate academic texts
- getting familiar with one of the most important theories on space and the urban in social sciences

On the occasion of the publication of the forthcoming book 'Henri Lefebvre and the Theory of the Production of Space' by Christian Schmid, we are organising a special seminar in the autumn semester 2022 in which we will read and discuss the book together.

Henri Lefebvre developed an extraordinarily and far-reaching spatio-temporal theory of society that is today widely applied in humanities and social sciences, particularly in urban studies, human geography, sociology, cultural anthropology, political sciences, philosophy, literature, cultural studies and the arts, and also in architecture, urban design and planning.

This book provides the first systematic reconstruction of Lefebvre’s theory of the production of space. While many receptions represent Lefebvre’s work as a collection of inspiring but disparate thoughts and reflections, this book starts from the thesis of coherence, assuming that this work is distinguished by a continuity of concepts and categories that are connected in a consistent way. It reveals the historical development of the core concepts. It illuminates Lefebvre’s understanding of everyday life, the right to the city, the thesis of the complete urbanization of society, and the intrinsic relationship between space and the state. It explains the famous double triad of the production of space: perceived, conceived and lived space – and spatial practice, representation of space and spaces of representation. And it develops a dialectical matrix of a theory of society, which is based on the core categories of spatio-temporal dimensions, levels, and configurations of social reality. It also gives an overview on the different Lefebvre receptions and discusses a wide range of applications of his concepts in various research fields.

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For further information see: https://www.versobooks.com/books/4089-henri-lefebvre-and-the-theory-of-the-production-of-space

The course will be held in English. Participants must be able to read and speak English.

In order to make the seminar open to a wider audience, we are organising it hybrid – over Zoom and in-person.

Places are limited. Please send a short application expressing your interest in the seminar to bathla@arch.ethz.ch

Henri Lefebvre developed an extraordinarily and far-reaching spatio-temporal theory of society that is today widely applied in humanities and social sciences, particularly in urban studies, human geography, sociology, cultural anthropology, political sciences, philosophy, literature, cultural studies and the arts, and also in architecture, urban design and planning.

This book provides the first systematic reconstruction of Lefebvre’s theory of the production of space. While many receptions represent Lefebvre’s work as a collection of inspiring but disparate thoughts and reflections, this book starts from the thesis of coherence, assuming that this work is distinguished by a continuity of concepts and categories that are connected in a consistent way. It reveals the historical development of the core concepts. It illuminates Lefebvre’s understanding of everyday life, the right to the city, the thesis of the complete urbanization of society, and the intrinsic relationship between space and the state. It explains the famous double triad of the production of space: perceived, conceived and lived space – and spatial practice, representation of space and spaces of representation. And it develops a dialectical matrix of a theory of society, which is based on the core categories of spatio-temporal dimensions, levels, and configurations of social reality. It also gives an overview on the different Lefebvre receptions and discusses a wide range of applications of his concepts in various research fields.

For further information see: https://www.versobooks.com/books/4089-henri-lefebvre-and-the-theory-of-the-production-of-space

The number of participants is limited to 40-50.

Participants will be expected to engage actively in:
- reading, debating and discussing a scholarly text
- acquiring new skills in reading and applying a theoretical text
- strengthening ability to read, present and debate academic texts
- getting familiar with one of the most important theories on space and the urban in social sciences

In order to make the seminar open to a wider audience, we are organising it hybrid – over Zoom and in-person.

Places are limited. Please send a short application expressing your interest in the seminar to bathla@arch.ethz.ch

Henri Lefebvre developed an extraordinarily and far-reaching spatio-temporal theory of society that is today widely applied in humanities and social sciences, particularly in urban studies, human geography, sociology, cultural anthropology, political sciences, philosophy, literature, cultural studies and the arts, and also in architecture, urban design and planning.

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Places are limited. Please send a short application expressing your interest in the seminar to bathla@arch.ethz.ch

The course will compose of lectures, practical crash courses in media use and storytelling, and fieldwork sessions. The course will aim to equip students with the basic tools and core principles to create short but complex experiments reflecting on urban space. This semester, the focus falls on the topic of video games, asking students to think about how filmmaking and digital animation skills may be used to tap into the multi-faceted possibilities presented by contemporary video gaming.

Using widely available recording tools and editing software, students will turn their fieldwork into short video or audio works of about 3-5 minutes.

NOTE: Students of this course will be given preference to the Semester Studio of the Chair of Architecture and Urban Design and Urban Studies (LUS) and if you attend a design course (V-IX) at the same time. Enrolling in this course is only possible on agreement with the lecturer and if you attend a design course (V-IX) at the same time.
students will reflect on the perception of the urban environment and the methods used to map and model the existing context – discussing, how different methodologies shape the way we perceive our environment. Therefore 3D tools such as laser scanning and photogrammetry will be tested in the field. Their application in the urban context and the workflow from scan to drawing will become known to the students.

This is the question that the teaching and research project Schnitt durch Zürich (Section through Zurich) has been investigating by the Chair of Laurent Staedler. As an Addition to the existing work, this course will create a section of the Uetliberg. In the course of methodical refinement 3D laser scanning and point cloud modeling methods, developed at the Chair of Christophe Girot are used to digitally model the topography and vegetation as well as pathways and buildings. Following the data collection the materials will be transferred to common CAD Software and reproduced in a section. Students will use scanners to scan the slopes and forests of the Uetliberg in fieldwork and get introduced to the workflow from scan to CAD drawing. This should give a tool for a better understanding of the existing context in future projects and thus broaden the students’ methodological scope.

Lecture notes:
- Learning Materials and Software Tutorials will be provided during the classes.
- Students will generally work in groups of 2

Literature:
- Literature will be provided during the course.

Prerequisites / notice:
The lectures will be held in English, assistance in English and German.

Competencies:

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Objective:

- General introduction: reconstruction approaches after conflicts and natural disasters
- Housing culture and post-tsunami reconstruction in Tamil Nadu, India
- Patterns of adaptation to culturally inadequate post-disaster housing
- Reconstruction challenges in rural and urban settings
- Housing reconstruction in rural and urban Nepal after the 2015 earthquake
- Rebuilding communities and schools in Haiti
- Learnings from postwar reconstruction in Kosovo
- Bottom-up housing initiatives in ongoing conflicts: the case of Ukraine
- Humanitarian planning: tackling emergency shelter needs.
- Housing initiatives in temporary camps

Lecture notes:
A course overview including lecture summaries is made available to inscribed students prior the start of the semester.

Literature:
A bibliography will be made available to inscribed students prior the start of the semester.

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052-0751-24L Topology ■

Abstract:
The elective course "Topology" in the Autumn Semester 2023 builds on a long standing specialization in the spatial exploration of the landscape. We will embark the participants on a terrain that we shape through our own thoughts and actions, adopting different perceptual perspectives, supported by examples from art, literature, technology and history.

Objective:
This elective course gives architecture students the opportunity to further develop their perception of space through a site-specific approach in the field of landscape architecture. The students will learn to use 3D point cloud technology and other spatial sensing technologies in order to analyze complex urban landscape and develop new ways of editing and representing these intertwined spaces.

Literature:
A bibliography will be made available to inscribed students prior the start of the semester.

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Content

Students will document and analyze a case-study site to reveal its topological potentials and sensory qualities. This understanding will be gained through point cloud modeling and audiovisual composition. In particular, we will develop a new, comprehensive sectional model of a topologically interesting site situation.

Students will become acquainted to working with point cloud models produced with laser-scanning. Through a series of steps, they will learn how a laser-scanning survey is conducted, how the raw data is processed, how point cloud models are assembled, what qualities these models can provide to analyze, explore and represent space as an audiovisual experience.

Collected samples from the field will be assembled and built into an interactive application in the «Landscape Visualization and Modelling Lab». All software required is open source and can also be installed on private laptops, facilitating work from home if necessary.

Lecture notes

Literature will be provided during the course.

Prerequisites / notice

- The course is limited to 20 students (based on available computer stations)
- Students will work in groups of 2
- The lectures will be held in English, assistance in English and German
- The enrolment will be prioritized by the time of inscription and balanced between departments

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Sensitivity to Diversity

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

Lecture notes

Literature will be provided during the course.

Prerequisites / notice

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Personal Competencies

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- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

My Garden’s Boundaries are the Horizon: A Case Study of Queer Gardens

W 2 credits 2S C. Baumann

Abstract

This course aims to raise awareness about the necessity to look at architectural history through a non-normative lens. The participants will be invited to explore the topic of queer gardens via the review of exemplary case studies. We will discuss how the shape of those gardens have been influenced by their owner’s personality and argue if such spaces share a common denominator.

Objective

Participants will conduct an analysis of case studies through the means of archival and iconographical research. They will also redraw the gardens in plans and sections in order to understand the specificity of those spaces. They will be invited to sharpen their critical thinking and debate the topic of queer gardens: Can one define the spatial criteria of such a typology? Does such a genre even exist? The outcome of this weekly elective course will be a presentation of the selected garden along with pictures, plans, section, a brief descriptive text and a bibliography list.

Content

“My garden’s boundaries are the horizon” (1) is one of the first sentence used by Derek Jarman, the late English artist, filmmaker and gay rights activist in the book Modern Nature to describe his small garden located in Dungeness, south Kent. The diary depicts Jarman’s artist life, his ordeal dealing with AIDS as well as his love for gardening. The word garden comes from the etymology “to guard” and is by definition an enclosed outdoor space. What a contradiction then to describe a garden, as Jarman’s does, by the absence of its limits! Dungeness has emerged over time as an exemplary reference of queer garden, but does such a typology even exists? And if it does, what are its characteristics?

“Growing up queer means experiencing the destabilising absence of broad and accessible queer history”.(2) Architecture as well as landscape architecture are far from exempt from this reality and there are little stories about queer landscapes to be found in the textbooks. In order to bridge this knowledge gap, we will study the gardens of openly queer personalities of the 20th and 21st century. The case studies will include, but not limited to, the followings:

- Casa Azul, Frida Kahlo, Mexico
- Dungeness, Derek Jarman, United Kingdom
- Majorelle Garden, Yves Saint-Laurent and Pierre Bergé, Morocco
- Sissinghurst, Vita Sackville-West, United Kingdom
- Temple de l’Amitié, Natalie Clifford Barney, Paris
- Villa Gamberaia, Florence Blood and Princess Ghyka, Italy

(1) Modern Nature, The Journals of Derek Jarman, Derek Jarman, Paperback, 2018
(2) Queer spaces, an Atlas of LGBTQ+ Places and Stories, Adam Nathaniel Furman and Joshua Mandell (Eds), Routledge, 2022

Literature

A bibliography specifically focused on queer spaces will be given at the beginning of the semester.

Prerequisites / notice

The assessment will be based on the following criteria: quality of the research, critical thinking, participation in the group discussions, and quality of the final presentation.

The number of participants is limited to 20. A short letter of motivation via mail is expected for application.

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Technologies in Architecture

Number  Title  Type  ECTS  Hours  Lecturers
151-8015-00L  Moisture Transport in Porous Media  W  3 credits  2G  J. Carmeliet, A. Kubilay, A. Rubin, D. A. Strebel


Objective: - Basic knowledge of moisture transport and related degradation processes in porous materials - Knowledge of experimental determination of moisture transport properties - Application of knowledge to moisture transport in cracked materials, drying of porous materials and microclimate in urban street canyons

Content:
1. Introduction
   - Moisture damage: problem statement, durability
   - Applications: building materials, soil science, geoscience
2. Moisture transport: theory and application
   - Description of moisture transport
   - Determination of moisture transport properties
   - Exercises on moisture transport properties
3. Special topics
   - Liquid transport in cracked materials, Drying of porous materials, Microclimate in urban street canyons

Lecture notes: Handouts, supporting material and exercises are provided online via Moodle.

Literature: All material is provided online via Moodle.

Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: fostered
  - Problem-solving: fostered
  - Project Management: fostered
- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: fostered
  - Leadership and Responsibility: fostered
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: fostered
  - Negotiation: fostered
- Personal Competencies
  - Adaptability and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

101-0577-00L  An Introduction to Sustainable Development in the Built Environment  W  3 credits  2G  G. Habert, E. Zea Escamilla

Abstract: In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. This decarbonization strategy is additional to Sustainable Development goals formulated the same year by the UN general assembly.

What does that mean for the built environment?
This course provides an introduction to the notion of sustainable development when applied to our built environment.
Subject-specific Competencies
The main focus of the diploma elective subject is in showing the building process by means of current examples of urban design with architectural relevance. Visits to construction sites and interdisciplinary lectures on the topics of communication, complexity, landscape and investment are the main focus of the workshop. The Chair views itself as the facilitator between those involved in construction and students. Active participation is a prerequisite.

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification
- Method 4: Material Flow Analysis

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

Lecture notes
All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

Objective
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmetal aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content
The following topics give an overview of the themes that are to be worked on during the lecture.
- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development and beyond

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification
- Method 4: Material Flow Analysis

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

Lecture notes
All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

052-0615-24L Building Process: Realization

Objective
Enrolment is only possible in agreement with the lecturer (eglin@arch.ethz.ch).

Abstract
Visits to construction sites and interdisciplinary lectures on the topics of communication, complexity, landscape and investment are the main focus of the workshop. In addition, the term process is to be depicted by means of visits to manufacturers of construction components.

Content
The main focus of the diploma elective subject is in showing the building process by means of current examples of urban design with architectural relevance. The Chair views itself as the facilitator between those involved in construction and students. Active participation is a prerequisite.

Lecture notes
The recordings of the lectures are available on the MAP under the link https://map.arch.ethz.ch (book symbol at the top right).

Literature
https://map.arch.ethz.ch

052-0629-24L CAAD Practice: Favela is City

Objective
After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content
The following topics give an overview of the themes that are to be worked on during the lecture.
- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development and beyond

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification
- Method 4: Material Flow Analysis

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

Lecture notes
All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

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Abstract
Visits to construction sites and interdisciplinary lectures on the topics of communication, complexity, landscape and investment are the main focus of the workshop. In addition, the term process is to be depicted by means of visits to manufacturers of construction components.

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Lecture notes
The recordings of the lectures are available on the MAP under the link https://map.arch.ethz.ch (book symbol at the top right).

Literature
https://map.arch.ethz.ch

Prerequisites / notice
The number of participants is limited and enrolment is only possible in agreement with the chair.

Introductory event: Participation in the introductory event is a prerequisite for this course!

Structure (Lectures, field work, final presentation) will be communicated in time.
1. To gain insight into informal urbanism and the prominent urban phenomenon of favelas, their inherent informality, dynamic nature, and the interplay between stability and change.
2. To develop the ability to decode the intricate fabric of favelas, to read the interrelationships between various elements, resources, and the nuanced rhythms of signals, noises, and uncertainties that define their urban landscapes.
3. To gain familiarity with AI algorithms as tools for exploring and interpreting favelas, employ images and textual analysis to uncover urban themes and issues these informal settlements embody.
4. To develop critical thinking skills, encouraging a deeper exploration of the underlying social, economic, and cultural factors at play.
5. To gain broader insights and generalisations from the study of favelas, to identify overarching principles that can contribute to the discourse on urbanism and informal settlements.
6. To enhance design fluency, effectively communicating complex ideas and interpretations through images and words, refining the ability to conceptualise and share favela ideas.
7. To develop the ethical dimensions of studying and representing informal urban environments.

Students will learn and engage with various modes of engagement with favelas using visual and written forms, becoming familiar with AI techniques and strategies to tackle both. By the end of the semester, students should have broadened their understanding of impoverished urban areas of the South and a clearer perspective on urban trends and opportunities in those areas. Using texts and images will develop competencies to be more effective visual communicators, understanding how to generate and manipulate images and text to express their ideas confidently, clearly, and precisely. Throughout the semester, students will write around 1000 to 2000 words and create self-organising maps using internet-sourced images guided by provided algorithms. Self-organising maps (SOMs) are an artificial neural network that helps visualise and group complex data by finding patterns and similarities, making it easier to understand and analyse large sets of information. Thus, a significant portion is dedicated to the data’s curation, editing, and publishing of the final assignment: a speculative exhibition that includes a poster and catalogue with a curator’s readings of favelas.

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052-0639-24L Climate Responsive Architecture with Hive

This Online course provides an introduction to climate-responsive design using the Hive tool and how to apply it in early building design stages. Hive allows architecture and building science students to understand the relation between architectural design, climate, comfort and energy. Hive is a plugin for the 3D modeling environment Rhino and its visual programming interface Grasshopper.

Objective

- Recall general principles of climate responsive design and examples of it.
- Utilize 3D building geometries to conduct simplified energy demand and supply simulations.
- Observe relevant physical principles and interactions between climate, energy and geometry.
- Implement passive and active concepts for Climate Responsive Design.
- Apply Hive for building design analysis and integrate it into own designs or in design courses.
- Identify and harness synergies and trade-offs between climate, energy and architectural design aspects.

Content

The course can be frequented individually, or as a prerequisite for other courses such as the master course Climate and Energy Systems 3 or architectural design studios.

Modules:
1. Course overview.
2. Introduction to climate responsive design.
3. Introduction to Rhino, Grasshopper and Hive.
4. Early solar analyses.
7. Real-world Applications and Examples.

Prerequisites / notice

No previous knowledge is required for joining this course.

This is a blended-learning self-paced ONLINE COURSE that can be started at any time.

A working Rhino 6 or 7 license is necessary.

052-0641-24L Digital Lexicon

The seminar focuses on the etymology and use of terms. It engages students to interrogate words and notions in order to understand the historical and theoretical implications related to the digital. The seminar aims to be a collective and shared work through the edition of a common lexicon.

Objective

Enlarge a background of historical knowledge and architectural culture. Develop a critical reflexion on tools and methods of digital design. Foster writing and synthesis skills and organize a collective publication.

Content

Is digital design a tool, a language, a content, a style, a dogma? In the last four decades the digital turn had a radical impact in the field of architecture from the conception to the fabrication stage, through different ways of representing and simulating space. Despite its recent history and a substantial rapid evolution, digital design is also naturally in continuity with previous techniques of craftsmanship and traditional design. Digital, computer, analog, virtual, artificial intelligence, smart technology, virtual reality, parametric design, rendering, modelization, auralization: to only name some of the most widely employed terms. The proposed seminar focuses on the theoretical definition of a recent although already dense and evolving vocabulary related to digital design. Building on the etymology of chosen terms and borrowing from a selected bibliography, we will edit a collective lexicon tackling the historical roots and theoretical implications of our everyday language employed in relation to the digital.
We expect students to achieve the following objectives at the end of the course:

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Cooperation and Teamwork: assessed
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-awareness and Self-reflection: assessed

**Future Cities Laboratory Indicia 03: Actions and Evidence for Future Settlements**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0653-24L</td>
<td>Future Cities Laboratory Indicia 03: Actions and Evidence for Future Settlements</td>
<td>2</td>
<td>S. Menz, J. Da Cruz Paulos, E. Suel</td>
</tr>
</tbody>
</table>

**Abstract**
The course is organised based on the Future Cities Laboratory (FCL) publication Indicia 03. Indicia 03 conveys the main research results as actions and guidelines for sustainable city-making. The course offers twelve thematic colloquia. It aims to introduce research outcomes of FCL and provide a platform for interdisciplinary knowledge exchange and critical thinking across domains.

**Objective**
We expect students to achieve the following objectives at the end of the course:
- Students learn about the main research results of FCL regarding sustainable urban development in an interdisciplinary format.
- Conversations with experts from different disciplines enable students to think critically and holistically about urbanisation and sustainability strategies from a global perspective.
- Through knowledge exchange and debates across disciplines, students explore and refine future studies/research in specific urban contexts.

**Content**
Planning and designing cities is complex and needs to address both short- and long-term sustainable development. The realisation of sustainability and resilience requires technology development with improved individual understandings and responsible actions, which brings with it challenges and great opportunities for change and transformation. FCL’s research covers multiple experiences and scales, from the individual citizen to larger communities and from small villages to megacities and offers important insights into the development of future settlements worldwide. This research has resulted in important Actions and Evidence required for the planning and design of future high-density, high-liveability cities published in Indicia 03.

The course consists of 12 colloquiums with specific themes that correspond to the chapters of Indicia 03. Each colloquium is joined by two to four external experts and FCL Global researchers from different disciplines to present their work. Moderated dialogues (debates and discussions) encourage students to explore the interrelationship between actions and guidelines as described in Indicia 03.

These include but are not limited to:
- Dialogue 1: Design Liveable Density
- Dialogue 2: Plan Variable Flows
- Dialogue 3: Partner with Nature
- Dialogue 4: Adopt Open Processes
- Dialogue 5: Harness Cyber-Physical Interactions
- Dialogue 6: Stimulate Diverse Economies
- Dialogue 7: Build Well
- Dialogue 8: Foster Settlement Systems
- Dialogue 9: Waterfront Tanjong Pagar: An Exploration in Transformative Design Research
- Dialogue 10: Cooling Singapore: Towards Urban Climate Design and Management
- Dialogue 11: Bioregion Java
- Dialogue 12: The Pandemic City

At the end of the course, students write an essay of 2,000 to 3,000 words based on one of the dialogues. The essays reflect the specific research content and actions described in Indicia 03 and address students' insights into sustainable urban development.

**Prerequisites / notice**
This elective course is organised with a focus on FCL Global research contents. We provide digital copies of the Indicia 03 for the students attending the course. The format of the course is the physical (at ETH Hönggerberg) and virtual. It will be open to all researchers and students in FCL Global, D-Arch and D-Baug.

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<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Lecturer</th>
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</thead>
<tbody>
<tr>
<td>052-0655-24L</td>
<td>Architectural Acoustics</td>
<td>3</td>
<td>A. Xydis, C. Frick, J. Strauss</td>
</tr>
</tbody>
</table>

**Abstract**
Every space, outdoor or indoor, exhibits different acoustic properties. These properties depend on the space's shape, size, and surface material; therefore, architects' design influences their resulting acoustical signature. This course introduces room acoustics and its applications in architecture and design.

**Objective**
The course lays out the theoretical background on how sound propagates in space, interacts with surfaces, and is ultimately perceived. Furthermore, hands-on exercises provide the tools to measure and analyse the acoustics of existing spaces and how to design and predict the acoustics of modelled spaces. The course provides a comprehensive understanding of acoustics and its practical applications in architecture, enabling students to apply their knowledge of acoustics in real-world scenarios.

**Content**
The course examines room acoustics and its applications in architecture and design. It introduces physiological and psychoacoustics by exploring audible space impressions in daily life and our ability to perceive and localise sounds. It provides the theoretical background on how sound propagates in space and interacts with surfaces by looking closely into reflection, absorption, and diffusion. It demonstrates basic mathematical and physics concepts such as decibels and reverberation time through practical examples and hands-on exercises.

The course examines how headphones and loudspeaker systems made electroacoustics and their application in room acoustics simulation and auralisation, a tool for acoustic design in architecture. It provides the software and hardware tools to measure and analyse the acoustics of existing spaces. It demonstrates acoustic simulation tools for designing and predicting the acoustics of digitally designed spaces.

Lectures by guest speakers round up the content and broaden the focus outside the box. Finally, the course concludes with a short seminar thesis, allowing students to apply their acquired knowledge to a small design project.

**Lecture notes**
The course format is a 1-hour lecture and a 2-hour hands-on exercise session.

**Prerequisites / notice**
The course takes place in the Immersive Design Laboratory (IDL) at HIT F22.
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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Integrated Discipline HS24 in the Field of Technology in Architecture (ITA)

**Title:** Integrated Discipline HS24 in the Field of Technology in Architecture (ITA)

**Type:** W

**ECTS:** 3 credits

**Hours:** 2A

**Supervisors:**

**Abstract:** This part of the curriculum addresses design work in different areas of architecture and urbanism and integrates the knowledge acquired in previous years. It involves the active participation of specialists from the chairs of the institute ITA.

**Objective:** Understanding of the importance of the ITA disciplines for architectural design and integration of structural thinking into the design process.

**Content:** This part of the curriculum addresses design work in different areas of architecture and urbanism and integrates the knowledge acquired in previous years. It involves the active participation of specialists from the chairs of the institute ITA.

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**Historic Building Archaeology and Conservation**

**Number:** 063-0961-24L

**Title:** Integrated Discipline HS24 in the Field Historic Building Archaeology and Conservation (IDB)

**Type:** W

**ECTS:** 3 credits

**Hours:** 2A

**Lecturers:**

**Supervisors**

**Abstract:** The formal framework needs to be discussed with the staff members.

**Objective:** A study in building research and preservation of building heritage with a clear topic.

**Content:** In addition to theory, heritage conservation also plays an important practical role in the current building revolution. In order to make the diverse possibilities in architecture visible, this course develops new strategies for communicating the discipline of monument preservation for an exhibition on this topic at S AM in 2025.

**Objective:** The aim of the seminar is to develop concepts for communicating and exhibiting heritage-related content and debates that go beyond specialist discourse and address a broader public. As part of the course, participants will acquire in-depth knowledge of various exhibition strategies in the field of architecture and will have the opportunity to develop exhibits for an exhibition organised by the S AM Swiss Architecture Museum (Basel) in collaboration with the Chair of Construction Heritage and Monument Preservation at ETH Zurich and ICOMOS Suisse in spring 2025.

**Content:** At a time when the maintenance of existing buildings is seen as an essential element of the building revolution, the theory and practice of heritage conservation is taking on an integral role. Nevertheless, heritage conservation still has to contend with image problems: people often misunderstand exactly what its aim is and, unaware of its mission, principles and (still highly topical) theories, the discipline is often assumed to have a purely conservative attitude. 50 years after the European Year of Monument Conservation in 1975, when the whole of Europe was dominated by the question of how to preserve the built heritage, there is no need for a fundamental repositioning, but there is certainly a need for an “update” on issues of monument conservation and its attitude in the face of current challenges. The joint exhibition at the S AM Swiss Architecture Museum in spring 2025 is dedicated to this topic. The course offers the opportunity to deal with architectural exhibition strategies and to participate in the development of various concepts for communicating the theory and practice of heritage conservation. New guiding principles for the future practice of heritage conservation will be jointly derived on the basis of best practice examples. In group work, current examples of successful cooperation between heritage conservation and architecture will be analyzed and documented for presentation in the exhibition in the form of drawings, texts and models. Depending on the number of participants, other parts of the exhibition can also be the subject of the work.

**Prerequisites / notice:** The course addresses primarily students of the MAS ETH in Denkmalpflege und Konstruktionsgeschichte and the CAS ETH in Future Heritage.
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

Method-specific Competencies
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: assessed

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

052-0911-24L  Repair: Keep in Place  W  2 credits  2S  S. Langenberg

This semester the elective (2KP) is offered in combination with a design studio (14KP) and an integrated design-build seminar week (2KP) in Davos on the Schatzalp. This course can only be taken in conjunction with 052-0923-24 U Architectural Design V-IX: Heritage-Led Teaching Project (GD A. Beer / D. Merz) and an integrated Design-Build seminar week. Please note: Registration for the elective is open until 18.09.2024. Please wait for enrolment and assignment of design studio.

Abstract
Complex constructions that are difficult to maintain and industrial manufacturing processes decrease the lifespan of objects not only in product design but also in architecture. Repairability is becoming less of a concern – replacement seems to be the norm. We need to rethink the way we build, starting already with the planning phase.

Objective
In this course, we combine traditional topics of preservation with concepts of repair and FAB initiatives to raise awareness for sustainable thinking and action. Students will learn both traditional and digital methods as well as the basic building and material criteria for repair. The objective is not only the hands-on repair of a building part but especially to learn about the concepts of heritage preservation.

Content
The elective course will discuss and examine the reparability of constructions and building systems. Students will identify building parts in need of maintenance and subsequently develop a repair concept. In groups, they will carry out the repair under expert guidance or possibly with the aid of digital fabrication processes. The objective is to recognize and analyze mechanisms of deterioration and to propose adequate repair measures.

Literature
Baier, Andrea u. a. (Hg.), Die Welt reparieren, Bielefeld 2016.
Krebs, Stefan u. a., Kulturen des Reparierens, Bielefeld 2018.
Langenberg, Silke (Hg.), Repair. Encouragement to Think and Make. Berlin 2018.

052-0915-24L  Building Surveying and Building Archaeology  W  2 credits  2G

Does not take place this semester.

Abstract
Surveying and measuring technologies in historical building archaeology. Case studies on building archaeology.

Objective
Basic understanding of different surveying methods and first practical contacts with technical surveys instruments. Understanding of the procedures and aims of building archaeology.

Content
From folding rule to laser scanner: surveying techniques and their possible applications.

The elective subject "Building Surveying and Building Archaeology" covers surveying and measurement methods ranging from simple hand measurements and tachymetry to laser scanning, terrestrial and drone-based photogrammetry (structure from motion) and other non-invasive assessment methods such as thermal imaging. The different methods and technologies will be presented on the basis of current or completed research projects and their practical applications will be discussed. Internal and external guest speakers will report on their latest research projects in the field of building research and construction history. In the course of the elective, students will also have the opportunity to try out the methods themselves and integrate them into a small concluding project of their own.

The course is composed of theoretical and practical parts in and outside the classroom.

Literature
Will be announced in the course for the individual lectures.
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Focus Works

see Architecture MSc "Focus Work"

Seminar Weeks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>052-1205-24L</td>
<td>Seminar Week Autumn Semester 2024</td>
<td>W</td>
<td>2 credits</td>
<td>3A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract
- The seminar week is obligatory for students of all semesters. There are many and varied study contents.
- The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ARCH

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Architecture Bachelor - Key for Type

| O | Compulsory |   | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | | Z | Courses outside the curriculum |
| W | Eligible for credits | | Dr | Suitable for doctorate |

Key for Hours

| V | lecture | | P | practical/laboratory course |
| G | lecture with exercise | | A | independent project |
| U | exercise | | D | diploma thesis |
| S | seminar | | R | revision course / private study |
| K | colloquium | | | |

ECTS

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Core Courses

### Field of History and Theory of Architecture

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This course is a reading class in which the architectural category of 'caractère' or character - a key concept in the 18th century but of great relevance until today - will be examined by a close reading of several key texts, from the late 1700s up until today. Independent reading and vivid discussion in class make up this course's character.</td>
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<td>Objective</td>
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<td>Deepen basic knowledge, improve ability to critically read and analyze texts of architectural theory, and understand shifts in architectural thinking.</td>
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<td>Content</td>
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<td></td>
<td>'Caractère' or character is not only a quality applied to human beings. It is also a category of architectural discourse, developed in the 18th century when architects and theorists were seeking new ways to talk about and judge buildings, pushing architectural discourse beyond Vitruvian categories to which it had been tied for centuries before.</td>
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This reading class will closely examine key texts that discuss the phenomenon of a building's 'character' from the 1700s up until today. The weekly assigned texts (in the original French, English or German) will be read at home and then discussed in class. Independent reading and vivid participation in class are a fundamental prerequisite. In addition, there will be weekly written assignments, which will all be graded. A final written assignment at the end of the semester will be graded as well. To pass the course, students will have to read each assigned text, and hand in all written assignments on time.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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</table>

**Method-specific Competencies**

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<tr>
<th>Competencies</th>
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<tbody>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td></td>
<td>Project Management</td>
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**Social Competencies**

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<tr>
<th>Competencies</th>
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<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Customer Orientation</td>
<td>fostered</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
<td>assessed</td>
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**Personal Competencies**

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<tbody>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<td>Self-direction and Self-management</td>
<td>assessed</td>
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<table>
<thead>
<tr>
<th>Number</th>
<th>History of Art and Architecture VII: Burning Down the House: Architecture and Political Dissent</th>
<th>W</th>
<th>2 credits</th>
<th>2V</th>
<th>M. Critchley, M. Delbeke</th>
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<tbody>
<tr>
<td></td>
<td>Abstract</td>
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<td>Through the close reading of specific case studies, this lecture course will examine how architecture's capacity to embody meaning is perhaps most explicit when it is violently destroyed through political dissent.</td>
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<td>Objective</td>
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<td>Deepen an understanding of political meaning in architecture including the methods and materials by which one can precisely research such meaning.</td>
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<td></td>
<td>Content</td>
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<td>When we talk about meaning in architecture we often begin with the architect, the patron or any number of contingencies which shaped a particular building's construction. But it is perhaps when architecture is violently destroyed that its capacity to embody meaning is most explicit. During acute periods of political dissent certain buildings have such a palpable entanglement with oppression that for certain groups their elimination almost becomes a necessity. In such moments architecture is suddenly transformed from an apparatus of control to an instrument of rebellion. Whether it is the burning of the 3rd precinct headquarters of the Minneapolis police after the murder of George Floyd or the storming of the Bastille, there is no ambiguity here. Stones, concrete and plaster become so loaded that all involved know precisely why they are raising them to the ground. When Black Jamaicans burnt down Morant Bay courthouse in 1865, they were very consciously attacking an object of imperial control. And when suffragette women bombed baroque churches in Britain they were bringing the fight to a religious-political structure which refused to give them the vote. In many of these cases, recourse to violence came only after it was clear that polite pleading was all too inadequate. Each week we will look in detail at the violent destruction of a specific building through political dissent. Where available we will turn to textual sources which record the voices of those who were committed to violent dissent against architecture but we will also recognise certain cases as acts of direct political speech through architecture by those to whom printed representation was not available.</td>
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<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>Scans of the readings relevant to each week's case study will be available on the course Moodle page.</td>
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</tbody>
</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 128 of 2667
Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

063-0803-24L History and Theory in Architecture IX: Earthworks: Art, Architecture, Ground
W 1 credit 1V P. Ursprung

Abstract
The current trend of architecture towards the ground and its materiality, the fascination for quarries, minerals, geology and the subterranean raises questions. How can one locate the phenomenon within the theoretical and historical discourse?

Objective
Increase knowledge of contemporary and historical discourse on architecture, art and the ground.

Content
Dwelling as a continuation of the Earth’s crust can be theorized from contemporary architecture back to Paleohistorical periods. The lecture will focus on various case studies of contemporary architecture and relate these phenomena to models of historiography and theory, and to earlier works of art and architecture. Which is the relation to the discussion of the Anthropocene? How does it affect perceptions of temporality and space? Which are the connections to earlier movements such as Land Art? How does it resonate with notions of infrastructure, extraction, and forms of power?

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

063-0805-24L History and Theory in Architecture IX: 1990s Theories that Inspired Architecture
W 1 credit 1V C. Nuijsink

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies fostered

Method-specific Competencies
Media and Digital Technologies assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

W 1 credit 1V M. Gnehm

Abstract
Is our Age of Algorithms the new Stone Age? The lecture course discusses such parallelization in architectural theory and practice from the nineteenth century to the present day.

Objective
The course conveys tools for the critical assessment of references to history in their theoretical and practical application in architecture.
The "invention" of the term "prehistory" and its corollaries such as "primal history" in the early nineteenth century shaped an image of science that architecture still reflects today. Architectural historicism was confronted with new depths of time, modernism was inspired by new concepts of origin. The "return to origins"; whether as a means of reflecting on historical truth or primal creativity, gave rise to a panoply of architectural manifestations and theoretical approaches. Architectural prehistory is often associated with a "prearchitectonic" world that articulated itself for instance in caves. However, when literary scholar Ann Bergren or philosopher Elizabeth Grosz speak of "prearchitectural" conditions, they are referring to a kind of mythical time in the sense of an eternal truth rather than to a long gone historical period. These positions seem to run parallel to the presence of archaisms in modern and contemporary architecture. Topics of the lecture course include Gottfried Semper's reflections on "antediluvian" societies and "prearchitectonic" cultural techniques; Walter Benjamin's "primal history of the nineteenth century"; nineteenth-century Egyptomania and twentieth-century reappraisals of Mayan architecture; the new Swiss sense of deep time that was awakened by the mid-nineteenth-century discovery of lacustrine dwellings on Switzerland's lakeshores and echoed in Le Corbusier's self-fashioning as a noble savage; Sigfried Giedion's encounters with the eternal present in the caves of Lascaux and Georges Bataille's pondering on today's loss of an environment which resembles the catastrophes that once buried prehistoric life.

From a 'cottage' in Chile, a 'tea equipage' in London, a 'veranda' in Mumbai, to a 'cathedral' in Strasbourg, this course presents global entanglements of built spaces while asking who we listen to when forming our understanding of architectural histories. By combining intersectional history with reception history, we ask: how and by whom were architectures also made? Through a set of lectures which are interspersed with exercises over the semester, students will engage with a diverse set of primary sources – texts, objects, sites – to actively re-think and re-read the past of the built environment. Lectures will present both theories and methods such as the global microhistory or collaborative reading.

This course encourages students to critically reflect on the relevance and critical importance of historical research for the present and the future. By completing this course, students will:
- develop an understanding of history as a living practice that shapes our present and future,
- deepen knowledge about local and global entanglements of buildings and objects,
- learn about concepts such as intersectional feminism, coloniality and decolonization,
- become familiar with historiographic methods such as the global microhistory or collaborative reading,
- improve both analytical and speculative writing skills.

This course introduces students to intersectional history – how accounts of the past are shaped by intersecting privileges and marginalizations – as well as reception history – how the meaning of architecture is and has been shaped also by those who dwell in it and use it. It draws heavily on the research of the ERC-funded group WoWA – Women Writing Architecture. It will focus, as the project, on the 18th and 19th centuries, complicating European histories within colonial contexts, especially linking to Latin America and the Indian subcontinent. However, it will also reach beyond this time frame to bring in a wider context – up to the Renaissance and into the 20th century. Through a set of lectures which are interspersed with exercises over the semester, students will engage with a diverse set of primary sources – texts, objects, sites – to actively re-think and re-read the past of the built environment. Lectures will present both theories and concepts such as intersectional feminism, critical race theory, (de- and post-) colonialism and coloniality, as well as showcase global microhistories of texts, objects, and sites that materialise the approach of intersectional histories. We reflect on what constitutes architecture – or architectures – from the point of view of the user, critic, and dweller. In several structured exercises, students will analyse an object, site, or text on both a micro and global scale, producing their own global microhistories over the semester. They will receive feedback and their work process and outcome will be graded.

This course is intended for students from the 5th semester onwards. Attendance is a key requirement. All readings will be available on Moodle.

For syllabus and readings, see https://www.gta.arch.ethz.ch

063-0863-24L Intersectional Histories: How Architectures Were Also Made

W 2 credits 2G A. Hultzsch

Abstract
From a 'cottage' in Chile, a 'tea equipage' in London, a 'veranda' in Mumbai, to a 'cathedral' in Strasbourg, this course presents global entanglements of built spaces while asking who we listen to when forming our understanding of architectural histories. By combining intersectional history with reception history, we ask: how and by whom were architectures also made?

Objective
This course encourages students to critically reflect on the relevance and critical importance of historical research for the present and the future. By completing this course, students will:
- develop an understanding of history as a living practice that shapes our present and future,
- deepen knowledge about local and global entanglements of buildings and objects,
- learn about concepts such as intersectional feminism, coloniality and decolonization,
- become familiar with historiographic methods such as the global microhistory or collaborative reading,
- improve both analytical and speculative writing skills.

Content
This course introduces students to intersectional history – how accounts of the past are shaped by intersecting privileges and marginalizations – as well as reception history – how the meaning of architecture is and has been shaped also by those who dwell in it and use it. It draws heavily on the research of the ERC-funded group WoWA – Women Writing Architecture. It will focus, as the project, on the 18th and 19th centuries, complicating European histories within colonial contexts, especially linking to Latin America and the Indian subcontinent. However, it will also reach beyond this time frame to bring in a wider context – up to the Renaissance and into the 20th century.

Through a set of lectures which are interspersed with exercises over the semester, students will engage with a diverse set of primary sources – texts, objects, sites – to actively re-think and re-read the past of the built environment. Lectures will present both theories and concepts such as intersectional feminism, critical race theory, (de- and post-) colonialism and coloniality, as well as showcase global microhistories of texts, objects, and sites that materialise the approach of intersectional histories. We reflect on what constitutes architecture – or architectures – from the point of view of the user, critic, and dweller. In several structured exercises, students will analyse an object, site, or text on both a micro and global scale, producing their own global microhistories over the semester. They will receive feedback and their work process and outcome will be graded.

Lecture notes
All readings will be available on Moodle.

Prerequisites / notice
This course is intended for students from the 5th semester onwards. Attendance is a key requirement.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
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<td>Self-direction and Self-management</td>
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Construction History: The Construction Site and Its Technology

History of the construction site and its technology will be announced during the introductory lectures.

Subject-specific Competencies

Analytical Competencies

Method-specific Competencies

Social Competencies

Personal Competencies

Case Studies Construction History and Building Preservation

Does not take place this semester. Each enrolment requires an uninterrupted visit throughout the semester. Cancellation (incl. deletion of enrolment) is permitted until x.x.2024.

Acquiring in-depth knowledge of construction history and building archeology by means of detailed study of selected historic monuments. The course will start with a multi-part classroom introduction, followed by field studies in small groups.

The participants will gain in-depth knowledge on the methodology of building archeology by means of the documentation and interpretation of real historic structures in on-site studies.

We study historic constructions in German-speaking Switzerland (individual small groups, objects within 2 hrs public transport reach from ETH Hoenggerberg). Each group will be assigned an individual tutor (PhD student) who will be present on-site, on individual appointment.

We will survey, document and analyze a historic construction, with particular attention to production traces, constructive detail and load-carrying system.

We will start with introductory classroom lectures and on-site teaching during the first third of the semester. This will be followed by individual digital investigations on site. The progress will be pinpointed in three critiques:

1) on site, with individual tutor
2) at institute, with professor and institute members
3) final delivery, at institute, with professor and all institute members

The detailed schedule of the case studies can be found here:


Detailed instructions on on-site investigations, as well as manuscripts on the background, will be provided. It is mandatory to read them in due time!

Each enrolment obliges the student to visit all compulsory dates during the entire semester without interruption.

Literature

Will be announced during the introductory lectures.
This class will NOT take place in fall term 2024, due to prof. Holzer's sabbatical.

The class will start again in spring term 2025, with a new concept and topic (roof trusses instead of bridges).

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: assessed

#### Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

### Future Monuments

#### 063-0911-24L

**Abstract**
Heritage conservation is dedicated to the preservation and protection of historical buildings. In this lecture, students will learn about the theoretical positions on historic monuments and the basics of preservation in practice.

**Objective**
In addition to active participation in the discussions, students will be asked to engage with a topic or object of their own choice in order to be able to develop and comprehensibly justify their own positions within the context of preservation. Our goal here is to foster students' communication skills and the culture of discussion.

**Content**
The responsible reconstruction and further development of the existing building stock requires knowledge and an understanding of the theoretical positions conservation and the basics of preservation in practice. The core course of spring semester 2024 conveys this knowledge to students with the help of selected writings and discusses them in the context of various guest lectures.
READING LIST

Monographs and edited volumes:


Dehio, Georg, Kunsthistorische Aufsätze. München 1914


Franz, Birgit, Gerhard Vinken and Johanna Blokker (Hg.), Denkmal - Werte - Bewertung. Denkmalpflege im Spannungsfeld von Fachinstitution und bürgerschaftlichem Engagement, Holzminden 2013 (Veröffentlichung des Arbeitskreises Theorie und Lehre der Denkmalpflege e.V., Band 23).

Huse, Norbert (Hg.), Denkmalpflege: Deutsche Texte aus drei Jahrhunderten, München 1984.

ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


Petzet, Michael und Gert Mader (Hg.), Praktische Denkmalpflege, Stuttgart/ Berlin/ Köln 1993.


Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


Wohlleben, Marion and Georg Mörsch, Georg Dehio und Alois Riegl - Konservieren, nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

Fundamentals and legal texts:

Stadt Zürich Hochbaudepartement, Amt für Städtebau, Denkmalpflege und Archäologie (Hg.), Schulhäuser der Stadt Zürich. Spezialinventar Archäologie und Denkmalpflege, September 2008

Stadt Zürich Hochbaudepartement, Amt für Städtebau (Hg.), Bauten, Gärten und Anlagen 1960 bis 1980. Inventarergänzung, August 2013


Die Kunstdenkmäler der Schweiz

INSA – Inventare der Heimatkantonen der Teilnehmenden
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: assessed

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Field of Landscape Architecture and Urban Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>063-0703-24L</td>
<td>Architecture of Territory: Territorial Design in Histories, Theories and Projects</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Topalovic</td>
</tr>
</tbody>
</table>

Abstract
This lecture series sets up an agenda for widening the disciplinary field of architecture and urbanism from their focus on the city, or the urban in the narrow sense, to wider territorial scales, which correspond to the increasing scales of contemporary urbanisation. It discusses the concepts of territory and urbanisation, and their implications for the work of architects and urbanists.

Objective
The course will enable students to critically discuss concepts of territory and urbanisation. It will invite students to revisit the history of architects’ work engaging with the problematic of urbanising territories and territorial organisation. The goal is to motivate and equip students to engage with territory in the present day and age, by setting out our contemporary urban agenda.

The lectures are animated by a series of visual and conceptual exercises, usually on A4 sheets of paper. All original student contributions will be collected and bound together, creating a unique book-object.

Content
The lecture series consists of 7 core lectures delivered by professor Milica Topalović, and 4 curated guest lectures highlighting a selected theme.

This fall, within the theme MY WEATHER, we will trace the uneven impacts of the environmental crises on the ground, and reflect on the entanglements of weather, atmosphere, and climate with the constructed environments and ecologies.

21. 09. 2023
On Territory
MILICA TOPALOVIĆ

28. 09. 2023
Architecture and Urbanisation
MILICA TOPALOVIĆ

05. 10. 2023
Methods in Territorial Research and Design
MILICA TOPALOVIĆ

19. 10. 2023
Title TBC
Guest lecture by MARCO FERRARI and ELISA PASQUAL – STUDIO FOLDER

02. 11. 2023
Planetary Urbanisation: Hinterland
MILICA TOPALOVIĆ

09. 11. 2023
Critical Walking
Curated walk by NAZLI TÜMERDEM

16. 11. 2023
Disappearance of the Countryside
MILICA TOPALOVIĆ

23. 11. 2023
Metropolitan Repair
MILICA TOPALOVIĆ

30. 11. 2023
Architecture is Climate
Guest lecture by ANTHONY POWIS and CHRISTINA SERIFI – MOULD

07. 12. 2023
Profiles of the Alps: Landschaft, Landscape, Paysage – Talschaft
Guest lecture by THOMAS KISSLING – STUDIO VOGT

14. 12. 2023
Our Common Territories: An Outlook
MILICA TOPALOVIĆ
Lecture notes

Team:
Prof. Milica Topalović, Dr. Nazlı Tümerdem

Student Assistants:
Giacomo Rossi

Contact:
Nazlı Tümerdem
tuerdem@arch.ethz.ch

Our website:
https://topalovic.arch.ethz.ch

Literature

- Wachsmuth, David. "City as Ideology: Reconciling the Explosion of the City Form with the Tenacity of the City Concept". Environment and Planning D: Society and Space 32(1), February 2014: pp. 75–90.

Prerequisites / notice

The lectures will take place on Thursdays, 10.00-12:00, at ONA Fokushalle E7.

80% attendance is required (9 sessions out of 11). The A4 exercises created during the lectures will count toward the attendance record.

The grading will be based on the attendance record and the three graded exercises.

Competencies

Subject-specific Competencies
- Methods of Urban Research: Extended Urbanisation: assessed

Method-specific Competencies
- Analytical Competencies: assessed

Social Competencies
- Communication: assessed
- Self-presentation and Social Influence: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-awareness and Self-reflection: assessed

063-0701-24L Methods of Urban Research: Extended Urbanisation W 2 credits 2G C. Schmid

Abstract

While architects, planners, and urban designers have engaged with the city, the analysis of urbanising territories ‘beyond the city’ have been a blind spot. This lecture series attempts to close this gap by discussing with researchers who will present methods, experiences and findings from a great variety of territories of extended urbanisation.

Objective

The lecture series ‘Methods of Urban Research: Extended Urbanisation’ presents the methodology of sociological analysis of territories of extended urbanisation. These territories, which have traditionally been beyond the sensorium of architecture and urban design professions provide important terrains for urban practice. The lecture series will bring together researchers that have been part of a long-standing research project on territories of extended urbanisation. They will present a kaleidoscopic overview of the diverse methods and insights into international research on urbanisation processes in large metropolises and in territories characterized by extended urbanisation. Most of the presented case studies are published in the brand new book “Extended Urbanisation: Tracing Planetary Struggles”.

Semester performance will be assessed on the basis of a written group assignment on extended urbanization (approximately 10 pages, in groups of four). For the assignment - describe and analyse an example of extended urbanization in a geography of your choice. The example may be from Switzerland or from any other region of the planet. Based on scientific literature and other data, conduct a critical analysis of the chosen case study, and discuss the consequences of urbanization of this area for its people and the environment. Develop a possible urban strategy for alternative inclusive development. Summarize your findings through a A3-sized poster.
Introduction: Christian Schmid

Content
- Contesting the dispossession of Land and Nature. The Peripheralisation of Arcadia - Metaxia Markaki
- The Horizontal Factory. The Operationalisation of the US Corn and Soy Belt - Nikos Kastikis
- Losing Sea. Abstraction and the End of the Commons in the North Sea - Nancy Couling
- The Mine, the City and the Encampment. Contesting Extractivism in Eastern Amazonia - Rodrigo Castriota
- Palm Oil and Extended Urbanisation in the Malaysian Hinterland - Hans Hortig
- Urbanisation en Route. The Lagos-Abidjan Corridor - Alice Herzog
- Extended Urbanisation in Guangt, South Africa - Lindsay Howe
- The Extended Urbanisation of Beijing - Yiqui Liu
- The Highway Revolution. Enclosure and State Space in India - Nitin Bathla

Concluding Discussion

Competencies

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103-0569-00L European Aspects of Spatial Development

W 3 credits 2G A. Peric Momcilovic

Abstract
Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Objective
Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making

Content
- European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system: EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the notion of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

Lecture notes
The documents for the lecture will be provided at the moodle.

Literature

Recommended literature:
- Governance models:

Planning systems in Europe:

EU as a political context:

Territorial cooperation in Europe:

Planning families and cultures:

EU as a political context:

Planning systems in Europe:

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Prerequisites / notice
Only for master students, otherwise a special permission by the lecturer is required.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Field of Technology in Architecture

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<tr>
<th>Number</th>
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<tr>
<td>151-8007-00L</td>
<td>Urban Physics</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>D. W. Brunner, H. Wernli</td>
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<td>Abstract</td>
<td>Urban physics: wind, wind comfort, pollutant dispersion, natural ventilation, driving rain, heat islands, climate change and weather conditions, urban acoustics and energy use in the urban context.</td>
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<tr>
<td>Objective</td>
<td>Basic knowledge of the global climate and the local microclimate around buildings</td>
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<td></td>
<td>Impact of urban environment on wind, ventilation, rain, pollutants, acoustics and energy, and their relation to comfort, durability, air quality and energy demand</td>
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<td></td>
<td>Application of urban physics concepts in urban design</td>
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<tr>
<td>Content</td>
<td>Climate Change. The Global Picture: global energy balance, global climate models, the IPCC process. Towards regional climate scenarios: role of spatial resolution, overview of approaches, hydrostatic RCMs, cloud-resolving RCMs</td>
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<td>Urban microclimate and comfort: urban heat island effect, wind flow and radiation in the built environment, convective heat transport modelling, heat balance and ventilation of urban spaces - impact of morphology, outdoor wind comfort, outdoor thermal comfort, urban energy and urban design. Energy performance of building quarters and cities, decentralized urban energy production and storage technologies, district heating networks, optimization of energy consumption at district level, effect of the micro climate, urban heat islands, and climate change on the energy performance of buildings and building blocks.</td>
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<td>Wind driving rain (WDR): WDR phenomena, WDR experimental and modeling, wind blocking effect, applications and moisture durability</td>
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<td>Pollutant dispersion. Pollutant cycle: emission, transport and deposition, air quality</td>
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<td>Prerequisites / notice</td>
<td>For MIBS Master students 151-8011-ooL Building Physics Theory &amp; Application is a pre-requisite for this course or instructor permission. For others no prior knowledge is required.</td>
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<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>G. Casas, F. Gramazio, H. Hassan, L. Wiedemeier</td>
</tr>
<tr>
<td>Abstract</td>
<td>&quot;Coding Architecture I-II&quot; is a programming class for architects with particular focus on demystifying technology - both software and hardware - and exploring the programmability of our world through powerful methods of digital, computational, and algorithmic design. This course welcomes students from all backgrounds, as no prior coding experience is required.</td>
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<tr>
<td>Objective</td>
<td>1. Understand essential concepts in programming and algorithmic thinking.</td>
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<td>2. Understand and apply powerful methods of digital, computational and algorithmic design.</td>
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<td>3. Apply digital technologies to design processes.</td>
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<td>4. Ability to understand a problem and create a solution in algorithmic terms.</td>
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<td>5. Ability to produce and implement novel and useful ideas.</td>
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<td>6. Materialize ideas into the physical world.</td>
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<tr>
<td>Content</td>
<td>Lectures, tutorials and exercises will focus on:</td>
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<tr>
<td></td>
<td>* Advanced Grasshopper usage as a continuation of Computational Design III-IV course.</td>
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<tr>
<td></td>
<td>* Build up basic proficiency in programming using Python.</td>
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<td></td>
<td>* Programming using Python within the design environment.</td>
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<td></td>
<td>* Applications in architecture and digital fabrication.</td>
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<td></td>
<td>* Familiarity with Grasshopper visual programming is expected.</td>
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<tr>
<td></td>
<td>* Course starts from the basics of programming, but moves quickly into advanced topics.</td>
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</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 137 of 2667
The course “Architektur und Tragwerk” represents an opportunity for architecture students to develop a design project in which load-bearing structures and architectural space support and enhance each other as inherent parts of the same design process. The demonstration of economic considerations within the design and construction process of buildings is the main focus of the diploma elective subject. Alongside determining basic principles, case studies play an important role in teaching. The economic factors of building construction are examined and the specific decision process is simulated. The case studies in the lectures as well as the processing of individual topics within the framework of elective work permit and require students active participation.

**063-0601-24L Building Process: Economy**

**W 2 credits 2G H. Reichel**

**Abstract**
The demonstration of economic considerations within the design and construction process of buildings is the main focus of the diploma elective subject.

**Objective**
To grasp the coherences of costs, income and income return.

**Content**
The demonstration of economic considerations within the design and construction process of buildings is the main focus of the diploma elective subject. Alongside determining basic principles, case studies play an important role in teaching. The economic factors of building construction are examined and the specific decision process is simulated. The case studies in the lectures as well as the processing of individual topics within the framework of elective work permit and require students active participation.

**Literature**
https://map.arch.ethz.ch

**Prerequisites / notice**
ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h:
Room: HB Open Space 2 (HIB E52) or online. Zoom link:
https://ethz.zoom.us/j/6684810727

Further information: http://www.bauprozess.arch.ethz.ch/education/MSc/BauprozessOekonomie.html

**063-0417-24L Architecture and Structure**

**W 3 credits 3G J. Pauli**

**Abstract**
The course “Architektur und Tragwerk” represents an opportunity for architecture students to develop a design project in which load-bearing structures and architectural space support and enhance each other as inherent parts of the same design process.

**Objective**
After a successful completion of the course, students will be able to:
1. Critically evaluate structural design concepts with respect to their ability to support and strengthen architectural concepts
2. Identify the most relevant design parameters and performance criteria for a given design task and select adequate tools to effectively integrate them as part of the design process
3. Conduct design explorations in compliance with structural, spatial, and environmental design aspects simultaneously

**Content**
The course “Architektur und Tragwerk” represents an opportunity for architecture students to develop a design project in which load-bearing structures and architectural space support and enhance each other as inherent parts of the same design process. The course fosters the development of a design thinking that emerges from the coexistence of a number of design parameters and performance criteria related to force flow, construction technologies, material use, and spatial qualities. Students will learn about diverse operative tools and strategies to control the complexity of such a multidisciplinary design process in which space-making and load-bearing elements are inherently intertwined. The potential of each design option will be evaluated based on various factors; in addition to structural performance and architectural expression, aspects related to material use, construction processes, and environmental footprint will play a crucial role in the whole process.

**063-0605-24L Computational Graphic Statics**

**W 3 credits 3G L. Enrique Monzo, P. Block**

To participate in this course it is recommended that the student has previously taken the courses
Tragwerkentwurf I-IV.
This course presents the potentials of combining graphic statics with computational tools.

- Use statics for the form finding and analysis of structures.
- Understand the goal and structure of an algorithm.
- Create algorithms based on graphic statics to explore equilibrium systems.
- Explain the potential of studying graphic statics models using computational tools.
- Use Interactive Graphic Statics (IGS2) for the analysis, form finding and design of 2D structures.
- Apply computational graphic statics in design contexts.
- Basic use of Rhinoceros and Grasshopper.
- Demonstrate elementary skills in Python scripting.

In this subject semester, we explore the topic of zero-emission building design, which integrates aspects of energy, materials, technology, human behavior, and comfort into architectural design and seeks synergetic design solutions. The practical potential and relevance of these methods will be demonstrated through various design-oriented tutorials and exercises.

All materials (lectures, tools, examples) are available on the A/S Knowledge Platform: https://moodle-app2.let.ethz.ch/course/view.php?id=11917

"Skript Tragwerksentwurf I&II"
http://www.block.arch.ethz.ch/eq/course/47?lang=en

"Faustformel Tragwerkentwurf" (Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2013, ISBN: 978-3-421-03904-0)


ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h:
Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

The application deadline for this "Fachsemester" is 5.9.2024, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class during the Master studies!

Choice of "Architectural Design" (from 05. Sem.) of the Bachelor course.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td></td>
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<td>Analytical Competencies</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<th>Number</th>
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<tr>
<td>063-0655-24L</td>
<td>Subject Semester HS24 (Fachsemester) in the Field of Technology in Architecture (Schlüter)</td>
<td>W</td>
<td>14 credits</td>
<td>29A</td>
<td>A. Schlüter</td>
</tr>
</tbody>
</table>

A student can only register once for a "Fachsemester" during the Master studies!

The application deadline for this "Fachsemester" is 4.9.2024, 8 p.m. You will receive a message about acceptance or rejection for the subject semester by 5.9.2024, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class (enrollment ends on 5.9.2024, at 6 p.m.).

In this subject semester, we explore the topic of zero-emission building design, which integrates aspects of energy, materials, technology, human behavior, and comfort into architectural design and seeks synergetic design solutions.

Upon successful completion of the subject semester, students will be able to identify concepts and relevant design parameters for zero-emission building design and develop integrated architectural design strategies. They will know how to select and use appropriate simulation and analysis tools to qualify and quantify their design solutions and will be able to visualize their concepts with both technical schematics and architectural drawings and visualizations.

The subject semester kicks off with an introduction to the use and exploitation of building systems for the design of zero-emission buildings. The goal of the semester is to demonstrate the relationships between building systems and architecture and to find ways to manifest building systems in design.

Students begin with a research and mapping phase in which they first investigate various building systems for zero-emission building design. They then map the building systems with architectural parameters for successful interaction between the two and create a catalog of their findings.

After the research and mapping phase, students design a small building in which they explore how to maximize the interactions between the building systems and the architectural parameters. Finally, students attempt to quantify their design solutions using low-threshold modeling, simulation, and optimization tools such as Rhino/Grasshopper or Hive. To assess and discuss their concepts not only numerically but also architecturally and aesthetically, students also find appropriate forms of visualization.

Students document the process and results both numerically and architecturally, which are then discussed with a final jury.

All materials (lectures, tools, examples) are available on the **A/S Knowledge Platform**: https://moodle-app2.let.ethz.ch/course/view.php?id=11917

All materials (lectures, tools, examples) are available on the **A/S Knowledge Platform**: https://moodle-app2.let.ethz.ch/course/view.php?id=11917
The working mode is an individual design research studio with weekly group meetings and reviews. We expect good basic knowledge of sustainable construction and energy and climate systems. Prior experience in parametric design tools (e.g. Rhino) and/or simulation tools is a plus.

Please note that a student can only register once for a subject semester during the master's program!

Apply with a brief letter of motivation by 8 pm on September 7, 2022 to: illias.hischier@arch.ethz.ch. Your participation in the subject semester will be confirmed by September 9, 2022.

The objective is to develop a design project that explores the historical entanglements of Swiss industry with global colonialism. This project will focus on the architecture-specific research methods, investigating how centuries of colonialism have historically influenced the aesthetic, construction and craft cultures of Swiss cities, and explores ways to engage with these contested legacies today.
Lecture notes

Methodology

The overarching hypothesis of this Research Studio is that historical and theoretical research can profit profoundly from the use of the tools and knowledge of architects. On the one hand, the spatial, formal, material, and constructive knowledge gained throughout architectural studies will guide the historical research in the archives, in the library, and/or in the city itself and will allow students to articulate specifically architectural interpretations of the materials they find. On the other hand, the Studio explicitly asks students to employ specific architectural tools such as drawing, writing and model-making to explore the historical and theoretical realities that are being investigated. By actively reflecting on the composition of a varied set of analytical and interpretative drawings, texts, and models, students will probe the capacity of these media to act as tools for historical and theoretical research.

Within the general theme of Swiss Coloniality, students will be guided to identify their own subtheme, which will require exploring their own specific research methodologies. These architecture-specific methodologies will be strategically chosen to discuss specific aspects of society: political, economic, social, cultural, or otherwise. Thus, conjointing these ‘autonomous’ and ‘heteronomous’ dimensions of architecture, a new understanding of the city and our built environment is developed that allows us to answer (some of) the research questions mentioned previously.

Research process

Students will be guided through three phases with different emphases: Definitions, Logics and Reinterpretations of Swiss Coloniality. The first phase, Definitions, is focused on developing an understanding of what the notion of Swiss Coloniality can entail and how it relates specifically to industry and the production of the city. This phase will allow students to become familiar with the historical and current entanglements of Switzerland with global colonialism and, by closely examining its main actors, practices, and materials, will set the stage for students to develop their own, individual research project.

The second phase, Logics, is about understanding and demonstrating the inner workings and mechanisms of Swiss Coloniality. Each of the students will focus on one specific case – a material, a site, an actor, a practice, etc. – and will examine it closely through targeted archival and library research, as well as through drawing, writing, and model-making.

In the third phase, Reinterpretations, students will formulate and investigate a hypothesis regarding the entanglements of Swiss industry with global colonialism. Based on this hypothesis, students will position themselves in relation to Swiss Coloniality, its history and its enduring impact. The position statement can take the form of a written text, architectural drawings and/or models and will be presented in the form of a student-curated studio exhibition and an online adaptation of it.

Course syllabus and reader will be made available during the course's first week.

Further course information on https://avermaete.arch.ethz.ch/researchstudio

The Research Studio is self-dependent work and tutoring takes place on Tuesdays and Wednesdays.

Fachsemester "Peace Out"

Allocation only after consultation with the professor (meetings as required and after consultation with the chair).

A student can only register once for a "Fachsemester" during the Master studies!

The application deadline for this "Fachsemester" is xxx, 8 p.m. You will receive a message about acceptance or rejection for the subject semester by xxx, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class (enrollment ends on xxx, at 6 p.m.)."

Abstract

In slang, “peace out” means “goodbye”. It also relates to the word “peace” which is, today, rarely used and hard to focus on. This double-meaning is the entry point for our Fachsemester. Can peace, in our present time, only be imagined as something that is over or yet to come? Are art or architecture peaceful as such? Does something like violent art or architecture exist?

Objective

Our aim is to increase the knowledge and sensitivity of architecture students toward the history of art and architecture, to make their voices heard and to develop new teaching formats for the history and theory of architecture. Students will learn to take position in a field, they will practice argumentation and increase their skills in writing and presenting.
In slang, “peace out” means “goodbye”. It also relates to the word “peace” which is, today, rarely used and hard to focus on. This double-meaning is the entry point for our Fachsemester. Can peace, in our present time, only be imagined as something that is over or yet to come? Are art or architecture peaceful as such? Does something like violent art or architecture exist? Starting with a visit to the almost forgotten Paxmal, a monument for peace initiated exactly 100 years ago by Karl Bickel high over Walensee, we will dive into the history of pacifism and look backwards, forward and to the present.

The Fachsemester in HS 2024 will deal with issues of ethics and esthetics in the largest sense. The syllabus will contain articles and book chapters on philosophy, performance, political science, poetry and history. Students are invited to develop their own texts in relation to the overall topic.

Our aim is to increase the facility of students for understanding spatial, political and historical interrelations. We support students to develop their skills in writing and reading, to make their voices heard, and to experiment, together with the teaching group, with new educational forms for the history and theory of art and architecture.

The group will meet on Wednesdays 10-13 at Kunsthalle Zürich and Thursdays 10-13 in our office.

Start: Wednesday, 18 September 2024.

Lecture notes
A Syllabus with source material for the lecture session will be provided.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
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<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
<td>Self-awareness and Self-reflection</td>
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<td>Sensitivity to Diversity</td>
<td>Self-direction and Self-management</td>
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<td>Negotiation</td>
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Subject Semester HS24 (Fachsemester) in the Field of History and Theory in Architecture (gta)

A student can only register once for a "Fachsemester" during the Master studies!

The application deadline for this "Fachsemester" is 4.9.2024, 8 p.m. You will receive a message about acceptance or rejection for the subject semester by 5.9.2024, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class (enrollment ends on 5.9.2024, at 6 p.m.).

Content

Meaning in architecture is often a more fraught question than in painting or literature. Architecture’s non-figurative nature may not appear as easy to read as the iconography of a painting or the narrative of a novel, but buildings do mean things and this meaning is inflected through audience and time. At its creation, occupation, or even violent destruction, architecture can embody all sorts of specific identifiable meanings, for definable even antagonistic groups.

We are interested in meaning in architecture in the widest possible sense. This Fachsemester is a place where you can pursue your own research interests. You come to us with a topic and we will help you develop it from initial idea, through focused research, ending with a carefully edited essay which you will deliver as a lecture at the end of the course. Weekly discussions will be focused on your research and how you can most quickly develop your own expertise. Complimentary talks will be given by members of Chair Delbeke where they will explain how they have conducted their own research from initial idea to published paper.
A student can only register once for a "Fachsemester" during the Master studies!

Places for this "Fachsemester" are limited. If you are interested in taking part, please send us an email with a 300-word motivation letter including an initial topic proposal to: professur.delbeke@gta.arch.ethz.ch

If you already have a specific case study in mind, please describe what this is. If not, you can describe a general idea or area of interest and we will help you find a more specific object of study during the course.

Proposals are open but might include: decoding the iconography of a particular building, historically and ideologically placing the ideas of a particular architect, studying a performance and its architectural setting, explaining the significance of a building during a specific political event, or reconstructing how the ideas of a particular group or class shaped a particular building or architectural type.

Our sole stipulation is that most or at least part of your work will focus on the period before 1900.

Deadline for applications is Wednesday September 6, 8 p.m. You will receive a message about acceptance or rejection for the subject semester by Thursday, September 7, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class (enrollment ends on September 7, at 6 p.m.).

Feel free to get in touch with us over summer if you would like to discuss your proposal in advance.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Focus Work**

Realization in the respective fields of the institutes. Definition of topics by professors, in consultation with the students. The content may also refer to an elective course.

**Field of Historic Building Research and Conservation**

Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>063-0951-24L</td>
<td>Focus Work HS24 in the Field of Historic Building Research and Conservation (IDB)</td>
<td>W</td>
<td>6 credits</td>
<td>13A</td>
<td>Supervisors</td>
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</tbody>
</table>

**Abstract**

Analysis of a single monument or a small group of interrelated monuments with the methods of archeological building research. Embedding of the objects studied into a context of construction history by means of archival and literature studies.

**Objective**

In-depth knowledge of the methods of archeological building research and construction history. Case-oriented in-depth knowledge of a selected historic building or construction type in its technical, social and economic setting and its architectural relevance.

**Content**

This study will require the in-depth analysis of a historic structure or a small group of structures. This includes an object documentation (survey drawings, photographic record, textual description). Contextual information to be researched by the methods of construction history (archival, literature).

**Prerequisites / notice**

The subjects can be proposed by the students. In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

**Field of Design and Architecture**

Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).

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<tr>
<th>Number</th>
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</thead>
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<tr>
<td>063-0551-24L</td>
<td>Focus Work HS24 in the Field of Design and Architecture (IEA)</td>
<td>W</td>
<td>6 credits</td>
<td>13A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

For supervision in the field of "Model and Design" choose the Study Director.

**Abstract**

IEA focus work, of which the content may also refer to an elective subject.

**Objective**

Development of skills and competences in a special area / sub-area of architectural theory or practice.
In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4. It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term “dropout”.

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one “in-depth study” course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The topic is determined in consultation with the chosen professor.

### Field of History and Theory of Architecture

**Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).**

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<tr>
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<tr>
<td>063-0851-24L</td>
<td>Focus Work HS24 in the Field of History and Theory in Architecture (gta)</td>
<td>W</td>
<td>6 credits</td>
<td>13A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

Indentation work of the Institute gta, of which the content can also refer to an elective subject.

The topic is determined in consultation with the chosen professor.

**Objective**

Development of skills and competences in a special area / sub-area of architectural theory or practice.

In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4. It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term “dropout”.

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one “in-depth study” course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The topic is determined in consultation with the chosen professor.

### Field of Landscape Architecture and Urban Studies

**Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>063-0751-24L</td>
<td>Focus Work HS24 in the Field Landscape and Urban Studies (LUS)</td>
<td>W</td>
<td>6 credits</td>
<td>13A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

Indentation work of the Institute LUS, of which the content can also refer to an elective subject.

The topic is determined in consultation with the chosen professor.

**Objective**

Development of skills and competences in a special area / sub-area of architectural theory or practice.

In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture). At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4. It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term “dropout”.

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one “in-depth study” course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The topic is determined in consultation with the chosen professor.
In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4.

It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term “dropout”.

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one “in-depth study” course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

Taking place from 10.-28.1.22 in ONA G25.

Field of Technology in Architecture

Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>063-0651-24L</td>
<td>Focus Work HS24 in the Field of Technology in Architecture (ITA)</td>
<td>W</td>
<td>6</td>
<td>13A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract

Indentation work of the Institute ITA of which the content can also refer to an elective subject.

The topic is determined in consultation with the chosen professor.

Objective

Development of skills and competences in a special area / sub-area of architectural theory or practice.

Content

In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4.

It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term “dropout”.

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one “in-depth study” course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The subjects can be proposed by the students.

Note: In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>063-0141-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>40D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;

b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Ultimate deadline to unsubscribe or enroll for the Master Thesis is 23.10.2024.

Deleting a reservation after this date is prohibited.
Abstract
The master's thesis is the completion of the Master's degree.

Objective
It shows the students' ability to work independently and is a proof of the successful completion of their studies.

Prerequisites / notice
The Master's thesis is supervised by a design professor D-ARCH. The students can choose one of the topics presented by the D-ARCH or - after approval by the head of the work - a free, self-chosen topic. Further details are regulated in Articles 31-38.

Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0559-24L</td>
<td>Analog Photography</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Barba</td>
</tr>
<tr>
<td>Abstract</td>
<td>Practice-oriented seminar on the topic of analog &amp; artistic photography</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Instructed by Nicolas Rolle, the seminar serves as an introduction to analog experimentation in the creative process of artistic practice. By analyzing the motifs and ways of thinking of photographers, the aim is to develop a basic approach to the medium of photography and to expand practical work in the darkroom through theoretical questions about the medium.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Theoretical and practical introductions form the core of the targeted exploration of the photographic apparatus. Students are encouraged to gather their own experiences in analog experiments and to explore the urban space and their surroundings with the camera. With an artistic work developed over the semester, the expanded concept of photography will be sharpened and brought to an individual expression.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Lecturer approval required for all students. Please send a letter of motivation (max. 300 words) to <a href="mailto:rolle@arch.ethz.ch">rolle@arch.ethz.ch</a> by 05.09.2024. The number of participants is limited to 20. The course will be held in German in the Fall Semester 2024.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competencies</td>
<td>Subject-specific Competencies: Concepts and Theories</td>
<td>fostered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Method-specific Competencies: Analytical Competencies</td>
<td>fostered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Competencies: Communication</td>
<td>fostered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal Competencies: Adaptability and Flexibility</td>
<td>fostered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>052-0579-24L</td>
<td>Understanding Light</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Barba, P. Anantha Murthy</td>
</tr>
<tr>
<td>Abstract</td>
<td>The seminar explores light from the perspectives of Physics and Art, opening up new dimensions for collaboration across disciplines by tackling questions such as: What is the origin and nature of light? How does it travel through space and time? How can it be made productive in an artistic sense and what, in turn, can artistic methodologies contribute to experimenting and thinking about light?</td>
<td></td>
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</tr>
</tbody>
</table>
| Objective | - Learn about the properties of light: intensities, phases, colors, and interactions with matter  
- Exploring optical effects: reflection, refraction, dispersion  
- Learn to plan and carry out an art project based on research inputs from other sciences  
- Enhancing conceptual and interdisciplinary thinking in unusual set-ups  
- Learn how to cope with unforeseen results and make random events productive for the successful implementation of a project  
- Fostering communication and presentation skills |      |      |       |                      |
| Content | In this course, we will set a performative frame for experimentation and exploration. Coupled with experiments in the Dep. of Physics, students will be introduced to concepts such as the origin of light and color, and the interpretation of the optical world that surrounds us to understand what actually gives rise to the effects we see everyday—from butterfly wings and autumn colors to the appearance of buildings and cities. In addition, we will perform practical experiments with basic optical components like lenses, mirrors, and prisms, in order to understand how they can be used to capture images. Inputs by guest lecturers (e.g. on light in photography, anthropology or urban landscapes) are planned. Students will be asked to present related topics. |      |      |       |                      |
| Prerequisites / notice | Max. number of participants: 15  
Please send a short motivation letter (max. 300 words) to artspaceandtime@arch.ethz.ch by 05 September 2024. |      |      |       |                      |
| Competencies | Subject-specific Competencies: Concepts and Theories | fostered |      |       |                      |
|             | Method-specific Competencies: Analytical Competencies | fostered |      |       |                      |
|             | Social Competencies: Communication | fostered |      |       |                      |
|             | Personal Competencies: Creative Thinking | fostered |      |       |                      |
| 063-0649-24L | Architectural Design with Machine Learning | W    | 2    | 2G    | A. Apolinarska |
| Abstract | This elective course presents machine-learning methods for data-driven design exploration in architectural design, and how to leverage them in combination with the parametric modelling paradigm. |      |      |       |                      |
| Objective | The students learn how to harness parametric models for data exploration and how to augment the design process with project-specific generative deep learning models. They acquire basic understanding of the underlying methods and can implement them in their design tasks in architecture, urban planning, engineering etc. |      |      |       |                      |
The course will cover the following topics: data exploration (analytics and visualisations), forward and inverse design problems (enhancing parametric modelling with machine learning), basics of machine learning (feed-forward networks, backpropagation), and generative models with special focus on autoencoders.

The course consists of lectures providing a theoretical background followed by hands-on practical sessions with coding exercises in Python and Grasshopper. In parallel, the students will work in small groups on a semester project, in which they apply the presented data-exploration and inverse design methods to a design task of their choice. Building upon the provided framework (in Grasshopper and Python), students will generate custom datasets and train project-specific models, and then use them for concept-phase design exploration.

Lecture notes
Slides and other materials will be provided during the course.

Prerequisites / notice
Literature will be provided during the course.
063-0669-00 Coding Architecture I, or 063-0670-00 Coding Architecture II, or equivalent programming fluency in Python and Grasshopper.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories assessed</td>
<td>Decision-making assessed</td>
</tr>
<tr>
<td>Techniques and Technologies assessed</td>
<td>Media and Digital Technologies assessed</td>
</tr>
<tr>
<td>Analytical Competencies fostered</td>
<td>Problem-solving assessed</td>
</tr>
<tr>
<td>Parametric Modelling with Machine Learning fostered</td>
<td>Project Management fostered</td>
</tr>
<tr>
<td>Analytical Competencies fostered</td>
<td>Method-specific Competencies</td>
</tr>
<tr>
<td>Decision-making assessed</td>
<td>Media and Digital Technologies assessed</td>
</tr>
<tr>
<td>Analytical Competencies fostered</td>
<td>Problem-solving assessed</td>
</tr>
<tr>
<td>Analytical Competencies fostered</td>
<td>Project Management fostered</td>
</tr>
</tbody>
</table>

Social Competencies
Communication fostered
Cooperation and Teamwork assessed
Leadership and Responsibility fostered

Personal Competencies
Critical Thinking fostered

101-0531-00L Digital Creativity for Circular Construction

All students who register go on a waiting list until 11.09.2024. To register:
1. Enroll before 05.09.2024
2. Send a short motivation letter (max. 300 words) and a 1-page CV to cea-course@ibi.baug.ethz.ch by 05.09.2024
3. MIBS students: This course is mandatory and there is no need to send your application documents

Please only register for the course if you really intend to participate on all course dates (see course catalog), otherwise, you will deprive someone else of a place.

Abstract
The course is about digital innovation towards a circular economy in the built environment. How can we bring together two worlds that are often too distinct: low-impact construction and digital innovation? Bringing digital tools already used in other sectors into the construction sector, students will learn about circular construction (e.g., reuse of materials) through hands-on learning practices.

Objective
In the fall semester 2024 we will focus on applying artificial intelligence (AI) and extended reality (XR) to the circular design workflow and evaluate possible solutions using digital technologies to enable a circular built environment (more specifically, with reused building materials). To achieve this, they need to be able to do the following:

1. Apply circular principles using recovered building materials.
2. Compare different digital technologies applied in circular construction (e.g., LiDAR scanning, drone imagery, photogrammetry, computational design, AI, computer vision, XR, LCA tools etc.)
3. Understand the potential and limitations of AI for circular construction, e.g. use machine learning to detect and digitize materials (computer vision) or to support creativity in the early design phases of circular construction (generative AI).
4. Communicate the importance and urgency of circular construction.
5. Assess the environmental impact implications of their design and technology decisions through a preliminary Life Cycle Assessment (LCA).

Content
Students will receive an introduction to circular principles by experts from the building industry and visit of (de-)construction sites where circular construction is exemplified. They will explore how to use digital technologies such as LiDAR scanning, photogrammetry, scan-to-BIM, computer vision, computational design, digital fabrication, blockchain technology and learn about the design implications using reclaimed building materials. This course is meant as an overview/introduction of many digital technologies that could be useful for circularity and gives the tools to students to further study the technologies they are most interested in on their own. Creativity in writing, filmmaking, design, construction, etc. is expected from the students. This course will give the tools to students to learn more on LCA if they wish to deepen their knowledge further.

Lecture notes
Language: English
Courses are on Tuesday afternoons in Kunsthalene or a room at ETH, but also require out-of-the-semester work and significant homework and site visits outside of class hours.

Literature
Prerequisites / notice

Interest in Digitalisation and Construction. Flexibility: This is a hands-on course, where students explore digital technologies and opportunities/challenges of reuse. Flexibility (e.g. adapting to unforeseen circumstances), responsibility (e.g. arriving on time for safety briefing), and spontaneity (e.g. finding innovative solutions) is expected from the students to adapt to the contingencies from demolition and construction sites with reused materials. The course is mandatory for MIBS students. If you are a first year MIBS student, please do not apply, you are automatically accepted. All other students from other departments should apply. Please only register for the course if you really intend to participate on all course dates (see course catalog). Please only register for the course if you are willing to send us a letter of motivation and really intend to participate; otherwise, you will deprive someone else of a place. All non-MIBS students who register go onto a waiting list until 11.09.2024 and up to 25 of them will be selected by the lecturer.

To register:
1. Enroll before 05.09.2024.
2. Send a short letter of motivation (max. 300 words) and a 1-page CV to cea-course@ibi.baug.ethz.ch by 05.09.2024.

Collaborators: Kunsthalle Zürich, ETH AI Center, Design++

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Problem-solving
- Project Management
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract

This seminar deals with writings by Walter Benjamin. On the one hand, his most famous and influential essays and fragments on critique, history and experience will be read and discussed, and on the other, a special focus will be placed on his thinking on architectural themes.

Objective

On the one hand, students learn to know Walter Benjamin’s most influential ideas, such as his views on art criticism, history and culture, as well as to reflect on his philosophical methods, such as thinking in constellations and pictures. On the other hand, students learn to apply Benjamin’s methods of interpretation (Deutung) to architectural works and the Benjaminian texts themselves.

Seminar Weeks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-1205-24L</td>
<td>Seminar Week Autumn Semester 2024</td>
<td>W</td>
<td>2</td>
<td>3A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

The seminar week is obligatory for students of all semesters. There are many and varied study contents. The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ARCH

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-1100-AAL</td>
<td>Architectural Design V-IX (Part 1)</td>
<td>E</td>
<td>14</td>
<td>16U</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php)

Project grading at semester end is based on the list of enrolments on 30.10.2024, (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

Session requirements.

Objective

Requirements.

Content

Session requirements.

052-1101-AAL | Architectural Design V-IX (Part 2) | E    | 14   | 16U   | Lecturers |

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php)

Project grading at semester end is based on the list of enrolments on 30.10.2024, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

### Abstract
Session requirements.

### Objective
Requirements.

### Content
Session requirements.

#### Architecture Master - Key for Type

<table>
<thead>
<tr>
<th></th>
<th>Compulsory</th>
<th>Eligible for credits and recommended</th>
<th>Eligible for credits</th>
<th>Recommended, not eligible for credits</th>
<th>Courses outside the curriculum</th>
<th>Suitable for doctorate</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>W+</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Key for Hours

<table>
<thead>
<tr>
<th></th>
<th>lecture</th>
<th>lecture with exercise</th>
<th>exercise</th>
<th>seminar</th>
<th>colloquium</th>
<th>practical/laboratory course</th>
<th>independent project</th>
<th>diploma thesis</th>
<th>revision course / private study</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>G</td>
<td>U</td>
<td>S</td>
<td>K</td>
<td></td>
<td>P</td>
<td>A</td>
<td>D</td>
<td>R</td>
</tr>
</tbody>
</table>

### ECTS
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Atmospheric and Climate Science Master

Modules

Weather Systems and Atmospheric Dynamics

See Module Weather Systems and Atmospheric Dynamics

Climate Processes and Feedbacks

See Module Climate Processes and Feedbacks

Atmospheric Composition and Cycles

See Module Atmospheric Composition and Cycles

Climate History and Paleoclimatology

See Module Climate History and Paleoclimatology

Hydrology and Water Cycle

See Module Hydrology and Water Cycle

Electives

The students are free to choose individually from the entire course offer of ETH Zürich and the universities of Zürich and Bern.

Weather Systems and Atmospheric Dynamics

Courses are only offered in Spring Semester.

Climate Processes and Feedbacks

Two additional courses are offered in Autumn Semester by University of Berne.

Atmospheric Composition and Cycles

Courses are only offered in Spring Semester.

Climate History and Paleoclimatology

Two courses are offered in Autumn Semester at University of Berne.

Hydrology and Water Cycle

see Elective courses Hydrology and Water Cycle (without Self-Learning Courses)

Prerequisites

The definition of prerequisites is part of the admission procedure for the master studies. You are informed by the admission office as to what courses of the section «prerequisites» you have to catch up with. You are accredited for these courses in the electives block of the master studies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0471-01L</td>
<td>Atmospheric Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Ammann, C. Heald, C. Mohr</td>
</tr>
</tbody>
</table>

Abstract

This course covers the chemical and physical processes controlling the composition of the troposphere and stratosphere and introduces the relevant fundamentals for processes in the gas phase, in aerosols and clouds. These concepts are explored in the context of key environmental issues, such as urban air pollution, stratospheric ozone depletion, and air quality connections to climate change.

Objective

1. describe the structure of the atmosphere and list atmospheric components and their main properties
2. define and describe the chemical and physical processes in the stratosphere and troposphere, follow reaction mechanisms, and apply rate laws
3. describe the physical and chemical principles of air pollution and summarize the most important legislative measures
4. discuss the local, regional, and global aspects of interactions between air quality, ecosystem health, and climate

Content

- Origin and properties of the atmosphere: composition (gases and aerosols), atmospheric structure, UV radiation, transport timescales
- Kinetics of gas phase reactions: rate laws, mechanisms of bimolecular and termolecular reactions.
- Stratospheric chemistry: Chapman cycle, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol
- Tropospheric chemistry: oxidizing capacity of the troposphere and the role of OH, oxidation and global budgets of CO and CH4, role of NOx, and the global tropospheric O3 budget
- Surface ozone chemistry: HOx-NOx cycle, role of VOCs, O3 isopleth, ozone production efficiency
- Aerosols: primary and secondary sources, composition, quantities and measures, connections to climate
- Multiphase chemistry: solubility of gases, Raoult’s Law and hygroscopicity, kinetics of gas to particle transfer, N2O5 chemistry, aqueous phase sulfur chemistry, secondary organic aerosol formation
- Air quality: role of planetary boundary layer, deposition processes, summer- versus winter-smog, environmental problems, legislation, long-term trends
- Global aspects: air quality - climate interactions

Lecture notes

Lecture materials (slides) are provided continuously during the semester, at least 2 days before each lecture. Annotations and corrections are provided at the latest within the same week.

Prerequisites / notice

Attendance of the lecture "Atmosphäre" LV 701-0023-00L or equivalent knowledge is a pre-requisite, and basic courses in physics and chemistry are expected.

On Mondays (or upon agreement) a tutorial is offered. This allows the students to discuss unresolved issues from the lecture or to discuss the problems of the exercise series and their solution. Participation is recommended.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-Atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes.

The students are able to:
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics.
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features.
- to explain how mountains influence the atmospheric flow on different scales.
- basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems.

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; North-Atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes.

Lecture slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=22731

An electronic version of this book can be obtained via the ETH library.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

The students are able to:
- to explain the mechanisms of convective storm formation using knowledge of thermodynamics and cloud microphysics.
- to interpret precipitation radar images.
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

In the course "Atmospheric Physics", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined. Measurement methods are taught as well.

The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to use thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in radiosonde ascents. Atmospheric mixing processes are introduced as a basis for fog formation. The concept of an air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

The students are able to:
- to explain orographic wind; planetary boundary layer; water isotopes.
- to explain the Atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind).

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

pdf-files of the revised book will be provided on moodle on a chapter-by-chapter basis.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

Additional Electives ETH

See recommended additional elective courses

Minors

Minor in Physical Glaciology

see Major in Atmosphere and Climate, MSc

Environmental Sciences

Minor in Biogeochemistry

See Module Biogeochemical Processes MSc in
### Minor in Global Change and Sustainability

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0015-00L</td>
<td>Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement</td>
<td>O</td>
<td>1 credit</td>
<td>1K</td>
<td>B. Vienni Baptista, C. E. Pohl, M. Stauffacher</td>
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</tbody>
</table>

**Abstract**

This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

**Objective**

Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, or how to secure broader impact of research. They learn to critically reflect their own research project in its societal context and on their role as scientists.

**Content**

The seminar covers the following topics:

1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

**Literature**


Further, this collection of tools will be used: https://naturalsciences.ch/topics/co-producing_knowledge https://www.shapetoolkit.eu

**Prerequisites / notice**

Participation in the course requires participants to be working on their own research project. Dates (Wednesdays, 8h15-12h00)

**Competencies**

- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

**Objective**

The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

**Literature**


Further, this collection of tools will be used: https://naturalsciences.ch/topics/co-producing_knowledge https://www.shapetoolkit.eu

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In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Training scientific writing skills.

Attendance is mandatory.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Decision-making</th>
<th>Project Management</th>
<th>Communication</th>
<th>Self-awareness and Self-reflection</th>
<th>Self-direction and Self-management</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
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<tr>
<td>Method-specific Competencies</td>
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<tr>
<td>Social Competencies</td>
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<td>Personal Competencies</td>
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<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
<th>Prerequisites / notice</th>
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<tbody>
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<td>Attendance is mandatory.</td>
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</table>

The master thesis is supervised by a professor of the D-ERDW or of the Institute for Atmosphere and Climate (IAC, D-USYS), a professor who teaches in the module subjects or a senior scientist who is on the list of "competent leaders of master theses" of the D-ERDW or of the D-USYS (associated with the IAC).

The master programme will be completed by a master thesis on a topic selected from the subject range of the chosen major programme. Students are to prove their skills in working autonomously on a scientific project. They document their work in a scientific report.

<table>
<thead>
<tr>
<th>Course Units for Additional Admission Requirements</th>
</tr>
</thead>
</table>

- Laboratory and Field Courses
  The course in the category «lab and field work» are only offered in spring semester.

- Master's Thesis
  The courses below are only available for MSc students with additional admission requirements.
701-0412-AAL Climate Systems
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction of the most important components of the climate systems and their interactions.

Objective
Students have a basic understanding of the global energy balance, radiation budget, boundary layer, atmosphere, ocean, biosphere, land-surface coupling, cryosphere, carbon cycle, climate variability, climate of the past and anthropogenic climate change, and they are able to apply this to solve simple quantitative problems and answer qualitative questions.

Lecture notes
Copies of the slides are provided in electronic form.

Prerequisites / notice
Teaching: Reto Knutti, several keynotes to special topics by other professors
Course taught in german, slides in english

701-0471-AAL Atmospheric Chemistry
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This is a self-study course targeted at Master students who did not follow the bachelor course "atmospheric chemistry" or equivalent, providing a general introduction into atmospheric chemistry. It introduces the relevant fundamental concepts, which are explored in the context of key environmental issues, such as air pollution, stratospheric ozone depletion, and connections to climate change.

Objective
At the end of this course, students are able to:
1. describe the structure of the atmosphere and list atmospheric components and their main properties
2. define and describe the chemical and physical processes in the stratosphere and troposphere, follow reaction mechanisms, and apply rate laws
3. describe the physical and chemical principles of air pollution and summarize the most important legislative measures
4. discuss the local, regional, and global aspects of interactions between air quality, ecosystem health, and climate

Content
- Origin and properties of the atmosphere: composition (gases and aerosols), atmospheric structure, UV radiation, transport timescales
- Kinetics of gas phase reactions: rate laws, mechanisms of bimolecular and termolecular reactions.
- Stratospheric chemistry: Chapman cycle, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol
- Tropospheric chemistry: oxidizing capacity of the troposphere and the role of OH, oxidation and global budgets of CO and CH4, role of NOx, and the global tropospheric O3 budget
- Surface ozone chemistry: HOx-NOx cycle, role of VOCs, O3 isopleth, ozone production efficiency
- Aerosols: primary and secondary sources, composition, quantities and measures, connections to climate
- Multiphase chemistry: solubility of gases, Raoult's Law and hygroscopicity, kinetics of gas to particle transfer, N2O5 chemistry, aqueous phase sulfur chemistry, secondary organic aerosol formation
- Air quality: role of planetary boundary layer, deposition processes, summer- versus winter-smog, environmental problems, legislation, long-term trends
- Global aspects: air quality - climate interactions

Lecture notes
The slides, notes and exercises of the preceding edition of the bachelor course 701-0471-01L Atmospheric Chemistry will be provided.

Prerequisites / notice
Basic courses in chemistry and physics are expected

Competencies

701-0475-AAL Atmospheric Physics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This is a self-study course for MSc students, who like to learn something about Atmospheric Physics but for cannot follow the course Atmosphärenphysik, because that is taught in German. However, the slides and the textbook of the course Atmosphärenphysik, and they form the basis also for this course.

Objective
See entry under LV 701-0475-00L Atmosphärenphysik

Content
See entry under LV 701-0475-00L Atmosphärenphysik

Lecture notes
Powerpoint slides and script from LV 701-0475-00L Atmosphärenphysik will be made available

Literature
pdf-files of the revised book will be provided as well.

Competencies

701-0473-AAL Weather Systems
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students),...
Abstract
The students learn about the dynamical features of the Earth's atmosphere. They interpret satellite imagery and learn about basic concepts in dynamical meteorology. The global circulation is briefly discussed, before introducing the Eulerian and the Lagrangian perspective, which are used to study air streams in extratropical cyclones and to investigate basic aspects in mountain meteorology.

Objective
The students are able to
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of the role of moist adiabatic processes for weather systems and why stable water isotopes are useful in this context

Content
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; potential vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer

Lecture notes
Lecture notes and slides

Literature
Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Social Competencies
Communication fostered

701-0106-AAL Mathematics V: Applied Deepening of Mathematics I - III
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Selected mathematical topics are presented for later use in more specialised lectures. Part of the topics were already discussed in the lectures Mathematics I-III. Here, they should be shortly recapitulated and most importantly applied to practical problems. If necessary, new mathematical concepts and methods will be introduced in order to solve challenging and inspiring problems from practice.

Objective
The aim of this lecture is to prepare the students for the more specialised lectures. They should become more familiar with the mathematical background, the mathematical concepts and most of all with their application and interpretation.

Content
Practical examples from the following areas will be discussed: ordinary differential equations; eigenvalue problems from linear algebra; systems of linear and nonlinear differential equations; partial differential equations (diffusion, transport, waves).

701-0071-AAL Mathematics III: Systems Analysis
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models; models in space and time.

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content
Introduction to principles of models; one-dimensional linear box models; multi-dimensional linear box models; nonlinear box models; models in space and time

Lecture notes
Teaching material: book (see literature).

Literature


Admissions and Credits

<table>
<thead>
<tr>
<th>Z</th>
<th>Courses outside the curriculum</th>
<th>W</th>
<th>Eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

Data: 02.07.2024 12:39
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Educational Science for Teaching Diploma and TC
These are the general course offerings of the programmes Teaching Diploma (TD) - categories Educational Science and Compulsory Elective Courses - and Teaching Certificate (TC) - category Educational Science.

► Educational Science Teaching Certificate

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
<td></td>
<td>2</td>
<td>V</td>
<td>E. Stern, M. Rau</td>
</tr>
<tr>
<td></td>
<td>This lecture is only apt for students who intend to enrol in the programs &quot;Teaching Diploma&quot; or &quot;Teaching Certificate&quot;. It is about learning in childhood and adolescence.</td>
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<td></td>
<td>Abstract</td>
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<td>This course looks into scientific theories and also empirical studies on human learning and relates them to the school.</td>
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<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
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<td>Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<td>Lernformen:</td>
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<td></td>
<td>Lecture notes</td>
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<td>Folien werden zur Verfügung gestellt.</td>
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<td>Literature</td>
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<td></td>
<td>Prerequisites / notice</td>
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</tbody>
</table>

| 871-0240-22L    | Coping with Psychosocial Demands of Teaching (EW4 W DZ)   |      | 2    | S     | S. Maurer, P. Caprez, I. Sargenti |
|                 | The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite. |
|                 | Abstract                                                  |      |      |       |                    |
|                 | In this class, students will learn concepts and skills for coping with psychosocial demands of teaching |
|                 | Objective                                                 |      |      |       |                    |
|                 | Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching. |
|                 | (1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks). |
|                 | (2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services). |

| 871-0242-06L    | Cognitively Activating Instructions in MINT Subjects W    |      | 2    | S     | R. Schumacher |
|                 | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |
|                 | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW1)". |
|                 | Abstract                                                  |      |      |       |                    |
|                 | This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. The mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance. |
|                 | Objective                                                 |      |      |       |                    |
|                 | - Get to know cognitively activating instructions in MINT subjects |
|                 | - Get information about recent literature on learning and instruction |
|                 | Prerequisites / notice                                   |      |      |       |                    |
|                 | Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht. |

| 871-0242-07L    | Human Intelligence W                                      |      | 1    | S     | E. Stern |
|                 | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |
|                 | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW1)". |
|                 | Abstract                                                  |      |      |       |                    |
|                 | The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed. |
|                 | Objective                                                 |      |      |       |                    |
|                 | - Understanding of research methods used in the empirical human sciences |
|                 | - Getting to know intelligence tests                      |
|                 | - Understanding findings relevant for education            |

| 871-0227-00L    | Foundations of the Theory of Science for Science Lessons W |      | 1    | S     | R. Schumacher |
|                 | Course for students of the Teaching Certificate and the Teaching Diploma without the subject of Sport. |
|                 | Abstract                                                  |      |      |       |                    |
|                 | When are experiments meaningful? How do we have to proceed to test hypotheses with experiments? By which criteria do we estimate the explanatory value of competing theories? To answer these questions the key to understanding scientific research. This seminar focuses on how these foundations can be taught in science lessons. |
Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar, 2) collaboration with elementary school teacher in a class, and 3) final report. Registration implies participation in all 3 parts.

Students learn more about the potential and challenges of pupils. They get to know the early stages of knowledge as well as the development of pre-concepts of students in their subject area. The seminar with a phase of cooperation consists of three phases: In the block seminar, pre-concepts are discussed in their own subject as well as theoretical inputs from developmental and cognitive psychology. During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students' level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

Subject-specific Competencies
Method-specific Competencies
Social Competencies
Personal Competencies

Disorders of Social Cognition

Enrolment possible with matriculation in
- Master HST
- Teaching Diploma or Teaching Certificate

This course unit can only be enrolled after successful participation in, or during enrolment in the course "Human Learning (EW1)".

Teaching Diploma Sports: allocation of the ECTS only possible in the category "Educational Science" !!!

In this seminar, we consider how the human brain processes social information. The approach focuses on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies from atypical populations, whose pathologies are typified by dysfunction in social information processing, such as autism spectrum disorder and schizophrenia.

- To familiarise students with forms of social cognition in humans, as well as the neural systems that support social cognition.
- To critically evaluate theories and data relating to Social Cognition and Social Neuroscience.
- To relate how knowledge of typical brain function can inform our understanding of individuals who process social information differently, and vice versa.
- To develop effective scientific communication skills in oral and written formats.

This seminar will consider how the human brain understands and organises social behaviour. The approach will focus on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies from atypical populations, whose pathologies are typified by dysfunction in social information processing. Examples of such pathologies include autism spectrum disorder, schizophrenia and attention deficit hyperactivity disorder. By examining healthy and atypical populations, this module will highlight how disorders of social cognition can inform the understanding of healthy brain function, as well as how understanding healthy brain function can inform disorders of social cognition.

Effectiveness Use of Visualisations for Learning

Successful completion of the lecture "871-0240-00L Human Learning (EW1)"


Seminar participants learn how to examine visualizations for their pedagogical impact. They will learn how to assess when it is worth using visualizations, how many visualizations should be offered, and how they can be embedded in teaching materials to avoid misconceptions and promote learning.

Visualizations are an integral part of STEM subjects. Visualizations can make learning content intuitively accessible. However, visualizations can also create misconceptions. For example, ball-and-stick models in chemistry can create the misconception that chemical bonds consist of static connections. In order to avoid such misconceptions, the seminar teaches effective instructional methods with visualizations. The seminar builds on theories from EW1. Practical exercises with various visualization methods (e.g. images, graphs, animations, simulations, interactive diagrams) will help seminar participants to create effective learning materials with visualizations for their own discipline.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 157 of 2667
### Educational Science Teaching Diploma

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern, M. Rau</td>
</tr>
</tbody>
</table>

**Abstract**

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

Thematische Schwerpunkte:
- Lernen als Verhaltensänderung und als Informationsverarbeitung
- Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information
- Lernen als Wissenskonstruktion und Kompetenzerwerb
- Lernen durch Instruktion und Erklärungen
- Die Rolle von Emotion und Motivation beim Lernen
- Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen

Lernformen:
- Theorien und wissenschaftliche Konstrukte werden zusammen mit ausgewählten wissenschaftlichen Untersuchungen in Form einer Vorlesung präsentiert.

**Lecture notes**

Folien werden zur Verfügung gestellt.

**Literature**


**Prerequisites / notice**

This lecture is only apt for students who intend to enrol in the programs “Lehrdiplom” or “Didaktisches Zertifikat”. It is about learning in childhood and adolescence.
**Abstract**

Students learn and practice techniques and skills for coping with psychosocial demands of teaching.

**Objective**

Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.

1. They know the basic rules of negotiation and conflict management (e.g., mediation) and can apply them in the school context (e.g., in conversations with parents).
2. They can apply diverse techniques of classroom management (e.g., prevention of disciplinary problems in the classroom) and know relevant authorities for further information (e.g., legal conditions; crisis intervention).
3. They know stress coping strategies to prevent burnout (e.g., psychosocial support) and are familiar with relevant institutions.

**Content**

**Major themes:**
- Counseling and counseling techniques
- Conflict management and mediation
- Classroom management
- Supporting students in a psychological crisis
- Preventing stress and burnout

**Forms of learning**

Theoretical foundations will be taught in workshops which contain different means of activation and interaction such as group work, panel discussions, and individual work. Subsequently, this knowledge will be transferred and applied in different school-related situations by means of role plays, discussing of cases and video sequences, as well as reflections of practical experiences.

**Literature**

Slides of the lecturer's presentations, supplementary materials, and materials for further reading are made available on Moodle.

**Prerequisites / notice**

The successful completion of ALL modules relevant for the teacher's diploma is required for participation in this course.

**Abstract**

The students have to read the book "Lernwirksam unterrichten" from Felten/Stern and they have to answer questions. In individual or small-group sessions will be discussed how insights from learning research can inform classroom practice.

**Objective**

Students know
- How to plan events and camps
- To assess curricula critically and to use them properly
- How to combine theoretical and practical issues in the 'Ergänzungsfach'

**Content**

1. LV Semestereinführung
2. LV Planung Outdoor-Weekend
3. LV Auswertung Outdoor-Event
4. LV Planung Event
5. LV Event-Präsentationen / Schlussveranstaltung

**Prerequisites / notice**

Enrolment only possible with matriculation in Teaching Diploma without the subject of Sport.

**Abstract**

The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

**Objective**

- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

**Data:** 02.07.2024 12:39  Autumn Semester 2024  Page 159 of 2667
Analytical Competencies

1. Assessing the adequacy of Matura thesis topics and defining the scope of a project.

2. Determining and promoting a successful work process.

3. Devising and applying criteria for assessing process, product and presentation of a Matura thesis.

Subject-specific Competencies

Concepts and Theories

Disorders of Social Cognition

- Teaching Diploma or Teaching Certificate

Enrolment possible with matriculation in Teaching Diploma or Teaching Certificate.

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1).

Abstract

In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

Objective

Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Content

Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:

- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

Prerequisites / notice

Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

Using Outdoor Education

Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.

Abstract

In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

Objective

- Get to know cognitively activating instructions in MINT subjects

Content

Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:

- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

Prerequisites / notice

Assessed

Formation of Knowledge in STEM Fields in Primary and Secondary School

Addresses to students enrolled either in Teaching Diploma (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enrolled after successful participation in the course 871-0240-00L "Human Learning (EW 1)".

Abstract

Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar (ca. 16 h), 2) collaboration with elementary school teacher in a class (ca. 34 h, with approx. 50% spent in the elementary or middle school class and ca. 50% for preparation), and 3) final report (ca. 10 h). Registration implies participation in all 3 parts.

Objective

1. Assessing the adequacy of Matura thesis topics and defining the scope of a project.
2. Determining and promoting a successful work process.
3. Devising and applying criteria for assessing process, product and presentation of a Matura thesis.

Prerequisites / notice

Focus on STEM subjects (biology, chemistry, computer science, mathematics, and physics) with no explicit discussion of geography or physical education.

Disorders of Social Cognition

Enrolment possible with matriculation in

- Master HST

- Teaching Diploma or Teaching Certificate

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)"

!! Teaching Diploma Sports: allocation of the ECTS only possible in the category "Educational Science"!!!

Abstract

In this seminar, we consider how the human brain processes social Information. The approach focuses on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies of dysfunction in social information processing, such as autism spectrum disorder and schizophrenia.
In this course options for implementing the specifications in the framework curriculum for the vocational baccalaureate are developed and fostered.

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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### Compulsory Elective Courses Teaching Diploma

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0237-01L</td>
<td>Lesson Design and School Development at Federal Vocational Baccalaureate Schools (UZH)</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>University lecturers</td>
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<tr>
<td></td>
<td>Enrolment only possible with Teaching Diploma matriculation.</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
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<tr>
<td></td>
<td>UZH Module Code: 090LLB1 (ATTENTION: Students of Sport Teaching Diploma enroll in course 090LLB1S)</td>
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<tr>
<td></td>
<td>Simultaneous enrolment in course &quot;Lernende an der Berufsmaturitätschule unterstützen und begleiten&quot; (UZH Module Code: 090LLB2) is compulsory.</td>
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<tr>
<td></td>
<td>Mind the enrolment deadlines at UZH:</td>
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<tr>
<td></td>
<td><a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline">https://www.uzh.ch/cmsssl/en/studies/application/deadline</a> s.html</td>
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<tr>
<td></td>
<td>(<em>Registering for studies at more than one university, Teaching Diploma</em>, Philosophische Fakultät)</td>
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<tr>
<td></td>
<td>Abstract: In this course options for implementing the specifications in the framework curriculum for the vocational baccalaureate are developed and discussed, e.g. guiding principles of BPM teaching, difficulties and challenges of interdisciplinary work. The module is designed for teachers at vocational baccalaureate schools and vocational schools of all disciplines.</td>
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<td>Objective: Students will be able to select subject content in their lessons based on vocational pedagogy, implement vocational pedagogical requirements for lesson design, incorporate interdisciplinary and cross-curricular approaches.</td>
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<td>- Students are familiar with various forms and procedures of performance assessment and feedback as well as lesson design. They are able to implement them, taking into account the different contexts in which young people live and work.</td>
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<tr>
<td></td>
<td>- Students are familiar with the content and significance of basic principles such as the vocational baccalaureate ordinance or school curricula and concepts such as sustainability, lifelong learning or error culture. They can use these aspects for school and teaching development and work cooperatively within the college.</td>
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</tbody>
</table>

| 871-0237-02L | Support and Accompany Learners at the Federal Vocational Baccalaureate School (UZH) | W    | 3    | 2S    | University lecturers |
|              | Enrolment only possible with Teaching Diploma matriculation. |      |      |       |                   |
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: 090LLB2

Simultaneous enrolment in course “Unterrichtsgestaltung und Schulentwicklung an Berufsmaturitätsschulen” (UZH Module Code: 090LLB1) is compulsory.

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html (*Registering for studies at more than one university, Teaching Diploma*, Philosophische Fakultät)

Abstract In this course, pedagogical processes are analyzed and learning and socialization processes are discussed using concrete case studies from teaching at vocational schools and vocational baccalaureate schools. The focus is on the supporting and encouraging role of the teacher and the consideration of the individual life and professional situations of the trainees in their heterogeneity.

Objective
- Students are familiar with a variety of approaches in the areas of individual support, internal differentiation, learning and problem-solving skills as well as constructive error and criticism culture. They are able to use them to promote learning.
- Students are aware of age- and development-typical problems of learners in education, can address them appropriately and involve counseling services and legal representation of young people appropriately.
- Students are able to relate their instructions to the students' learning experiences in professional practice and to their various life and work contexts, and to incorporate them as a starting point for school-based and lifelong learning processes.
- Students can describe and explain the experience and behaviour of adolescents at school and the world of work from different perspectives.

**871-0242-06L**

**Cognitively Activating Instructions in MINT Subjects**

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.

Abstract This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

**871-0229-00L**

**Using Outdoor Education**

Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.

Abstract In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

Objective Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Content
- Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:
  - Forest Soil: The soil in the focus of the climate
  - Photosynthesis/Climate change: The tracks in the forest
  - Dendrochronology: What annual rings tell
  - Dendrochronology: What annual rings tell

**871-0242-07L**

**Human Intelligence**

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.

Abstract The focus will be on the book “Intelligenz: Grosse Unterschiede und ihre Folgen” by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

Objective
- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

**871-0227-00L**

**Foundations of the Theory of Science for Science Lessons**

Course for students of the Teaching Certificate and the Teaching Diploma without the subject of Sport.

Abstract When are experiments meaningful? How do we have to proceed to test hypotheses with experiments? By which criteria do we estimate the explanatory value of competing theories? The answers to these questions are the key to understanding scientific research. This seminar focuses on how these foundations can be taught in science lessons.

Objective
- an overview of the most important models in the theory of science
- expertise to implement and discuss these models in science lessons

**871-0240-27L**

**Supervising and Assessing Matura Theses**

Prerequisites: successful participation in 871-0240-00L “Human Learning (EW1)”.

Abstract This course prepares prospective teachers to supervising and assessing scientific projects at upper secondary school level, particularly Matura theses in STEM subjects at Gymnasium.

Objective
1. Assessing the adequacy of Matura thesis topics and defining the scope of a project.
2. Determining and promoting a successful work process.
3. Devising and applying criteria for assessing process, product and presentation of a Matura thesis.
871-0226-00L  Effective Use of Visualisations for Learning

<table>
<thead>
<tr>
<th>Content</th>
<th>Objective</th>
<th>Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visualizations are an integral part of STEM subjects. Visualizations can make learning content intuitively accessible. However, visualizations can also create misconceptions. For example, ball-and-stick models in chemistry can create the misconception that chemical bonds consist of static connections. In order to avoid such misconceptions, the seminar teaches effective instructional methods with visualizations. The seminar builds on theories from EW1. Practical exercises with various visualization methods (e.g. images, graphs, animations, simulations, interactive diagrams) will help seminar participants to create effective learning materials with visualizations for their own discipline.</td>
<td>- To develop effective scientific communication skills in oral and written formats.</td>
<td>In this seminar, we consider how the human brain processes social information. The approach focuses on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies from atypical populations, whose pathologies are typified by dysfunction in social information processing, such as autism spectrum disorder and schizophrenia. The seminar will consider how the human brain understands and organises social behaviour. The approach will focus on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies from atypical populations, whose pathologies are typified by dysfunction in social information processing. Examples of such pathologies include autism spectrum disorder, schizophrenia and attention deficit hyperactivity disorder. By examining healthy and atypical populations, this module will highlight how disorders of social cognition can inform the understanding of healthy brain function, as well as how understanding healthy brain function can inform disorders of social cognition.</td>
</tr>
</tbody>
</table>

Competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
- Social Competencies
  - Communication: fostered
  - Cooperation and Teamwork: fostered
  - Self-presentation and Social Influence: assessed
- Personal Competencies
  - Adaptability and Flexibility: fostered
  - Critical Thinking: fostered
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

Educational Science for Teaching Diploma and TC - Key for Type

- **O** Compulsory
- **W+** Eligible for credits and recommended
- **W** Eligible for credits
- **E-** Recommended, not eligible for credits
- **Z** Courses outside the curriculum
- **Dr** Suitable for doctorate

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>ECTS</th>
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</thead>
<tbody>
<tr>
<td>L lecture</td>
<td></td>
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<tr>
<td>G lecture with exercise</td>
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<tr>
<td>U exercise</td>
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<tr>
<td>S seminar</td>
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<tr>
<td>K colloquium</td>
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<tr>
<td>P practical/laboratory course</td>
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<tr>
<td>A independent project</td>
<td></td>
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<tr>
<td>D diploma thesis</td>
<td></td>
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<tr>
<td>R revision course / private study</td>
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</tbody>
</table>

Special students and auditors need special permission from the lecturers.
Civil Engineering (General Courses)

Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-1187-00L</td>
<td>Colloquium in Structural Engineering (Autumn Semester)</td>
<td>W</td>
<td>1 credit</td>
<td>2K</td>
<td>A. Taras, E. Chatzi, A. Frangi, W. Kaufmann, B. Stojadinovic, B. Sudret, M. Vassiliou</td>
</tr>
</tbody>
</table>

Abstract
Professors from national and international universities, technical experts from the industry as well as research associates of the institute of structural engineering (IBK) are invited to present recent research results and specific projects from the practice. This colloquium is addressed to members of universities, practicing engineers and interested persons in general.

Objective
Learn about recent research results in structural engineering.

Content
Learn about recent research results and novel practical applications & methods in structural engineering.

Competencies
Subject-specific Competencies: Concepts and Theories, assessed
Method-specific Competencies: Problem-solving, fostered
Social Competencies: Communication, fostered

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-1387-00L</td>
<td>Colloquia in Geotechnics</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>A. Puzrin, G. Anagnostou, I. Anastasopoulos</td>
</tr>
</tbody>
</table>

Abstract
The Institute for Geotechnical Engineering invites distinguished speakers from research and practice, nationally and internationally. The colloquia are directed towards staff and students from Universities as well as engineers and scientists working in industry. Details can be obtained from www.igt.ethz.ch by following Events & Public Events. Some colloquia are available via webcast.

Objective
Learn about recent research results in geotechnics.

Civil Engineering (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Civil Engineering Bachelor

##### First Year Compulsory Courses

#### First Year Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0141-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5 credits</td>
<td>4V+1U</td>
<td>M. Akka Ginosar, R. Prohaska</td>
</tr>
<tr>
<td></td>
<td>Introduction to Linear Algebra</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basic knowledge of linear algebra as a tool for solving engineering problems.</td>
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</tr>
<tr>
<td></td>
<td><strong>Objective</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Understanding of abstract mathematical formulation of technical and scientific problems. Together with Analysis we develop the basic mathematical knowledge for an engineer.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Content</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces.</td>
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</tr>
<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
<td></td>
<td></td>
<td></td>
<td>The lecturer will provide course notes.</td>
</tr>
<tr>
<td></td>
<td><strong>Literature</strong></td>
<td></td>
<td></td>
<td></td>
<td>K. Nipp, D. Stoffer, Lineare Algebra, VdF Hochschulverlag ETH</td>
</tr>
<tr>
<td>151-0501-03L</td>
<td>Mechanics I</td>
<td>O</td>
<td>6 credits</td>
<td>3V+2U+1K</td>
<td>R. Hopf, E. Mazza</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Basics: Position of a material point, velocity, kinematics of rigid bodies, forces, reaction principle, mechanical power</td>
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</tr>
<tr>
<td></td>
<td>Statics: Groups of forces, moments, equilibrium of rigid bodies, reactions at supports, parallel forces, center of gravity, statics of systems, principle of virtual power, trusses, frames, forces in beams and cables, friction.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td><strong>Objective</strong></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>The understanding of the fundamentals of statics for engineers and their application in simple settings.</td>
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</tr>
<tr>
<td></td>
<td><strong>Content</strong></td>
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</tr>
<tr>
<td></td>
<td>Grundlagen: Lage eines materiellen Punktes; Geschwindigkeit; Kinematik starrer Körper; Translation, Rotation, Kreiselung, ebene Bewegung; Kräfte, Reaktionsprinzip, innere und äussere Kräfte, verteilte Flächen- und Raumkräfte; Leistung</td>
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<tr>
<td></td>
<td>Statik: Äquivalenz und Reduktion von Kräftegruppen; Ruhe und Gleichtgewicht, Hauptsatz der Statik; Lagerbindungen und Lagerkräfte, Lager bei Balkenträgern und Wellen, Vorgehen zur Ermittlung der Lagerkräfte, Parallele Kräfte und Schwerpunkt; Statik der Systeme, Behandlung mit Hauptsatz, mit Prinzip der virtuellen Leistungen, statisch unbestimmte Systeme; Statisch bestimmte Fachwerke, ideale Fachwerke, Pendelstützen, Knotengleichgewicht, räumliche Fachwerke; Reibung, Haftreibung, Gleitreibung, Gelenk und Lagerreibung, Rollreibung; Seilstatik; Beanspruchung in Stabträgern, Querkraft, Normalkraft, Biege- und Torsionsmoment</td>
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</tr>
<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
<td></td>
<td></td>
<td></td>
<td>Übungsblätter</td>
</tr>
<tr>
<td></td>
<td><strong>Literature</strong></td>
<td></td>
<td></td>
<td></td>
<td>Sayir, M.B., Dual J., Kaufmann S., Mazza E., Ingenieurmechanik 1: Grundlagen und Statik, Springer</td>
</tr>
<tr>
<td>651-0032-00L</td>
<td>Geology and Petrography</td>
<td>O</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>K. Rauchenstein, M. O. Saar</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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</tr>
<tr>
<td></td>
<td>This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. The course consists of weekly lectures and bi-weekly exercises in groups.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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</tr>
<tr>
<td></td>
<td>This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
<td></td>
<td></td>
<td></td>
<td>Übungen zum Gesteinsbestimmen und Lesen von geologischen, tektonischen und geotechnischen Karten, einfache Konstruktionen.</td>
</tr>
<tr>
<td></td>
<td><strong>Literature</strong></td>
<td></td>
<td></td>
<td></td>
<td>Weekly handouts of PPT slides via MyStudies</td>
</tr>
<tr>
<td>101-0700-00L</td>
<td>Programming for Engineers</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>B. Sudret, N. Lüthen</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>This course is a hands-on introduction to programming with Matlab and Python, oriented at the needs of civil engineers. The course is held in a novel format comprising self-paced tutorials, a project consisting of implementing an engineering application including graphical user interface, and individual meetings with teaching assistants to demonstrate understanding and progress.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Students recognize the usefulness and power of computer tools in civil engineering, and are prepared to independently use Matlab or Python for solving relevant engineering problems.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Students are able to explain basic computer science concepts in simple terms.</td>
<td></td>
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<tr>
<td></td>
<td>• Students are able to understand and explain the functionality of existing code.</td>
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<tr>
<td></td>
<td>• Students are able to analyse a simple civil engineering problem in order to partition it into logical blocks and devise an algorithm to systematically solve the problem.</td>
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<tr>
<td></td>
<td>• Students are able to implement simple imperative (non-recursive) algorithms in Matlab and Python and explain the functionalities of their code. They are able to extend existing code with new functionalities.</td>
<td></td>
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<tr>
<td></td>
<td>• Students are able to validate, test and debug their own code as well as existing code.</td>
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<tr>
<td></td>
<td>• Students are able to explain the basics of object-oriented and interactive programming and are able to extend existing skeleton code to create simple graphical user interfaces.</td>
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</tr>
</tbody>
</table>

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Data: 02.07.2024 12:39  
Autumn Semester 2024  
Page 165 of 2667
The course is structured into six modules. The first five are using Matlab, while the last introduces Python.

1. Getting to know Matlab: Matlab as a calculator; variables and arrays
2. Programming basics I: iterating and branching
3. Programming basics II: input and output, functions, visualization
4. Introduction to scientific programming: implementing simple algorithms from numerics, statistics and discrete math; validation, testing and debugging
5. From structures to objects to GUI: basics of object-oriented programming, introduction to interactive programming and graphical user interfaces (GUI)

6. Introduction to programming with Python

A script will be provided. The students will discover the topics of each module through E.Tutorials that they will follow at their own pace online.

The course Private Law focuses on the Swiss Code of Obligations (contracts, torts) and on Property Law (ownership, mortgage and easements). In addition, the course will provide a short overview of Civil Procedure and Enforcement.

The course Private Construction Law

As future construction practitioners, students are able to recognise legal problems independently and in good time in their daily work and to initiate the right measures.

The class Introduction to Civil Law introduces to practice-relevant basics of construction and real estate law.

Mathematics as a tool to solve engineering problems. Mathematical formulation of technical and scientific problems.

Simple Mathematical models in engineering.

Calculus for functions of one variable with applications.

Basic mathematical knowledge for engineers.

- Con riassunti in italiano. E possibile sostenere l'esame in italiano.
- Examen au 1er propédeutique; convient pour travail de semestre.
- Les examens peuvent se faire en français ou en italien.
- What else to know ...

- The course Private Law focuses on the Swiss Code of Obligations (contracts, torts) and on Property Law (ownership, mortgage and easements). In addition, the course will provide a short overview of Civil Procedure and Enforcement.

- The course Private Construction Law

- As future construction practitioners, students are able to recognise legal problems independently and in good time in their daily work and to initiate the right measures.

- The class Introduction to Civil Law introduces to practice-relevant basics of construction and real estate law.

First Year Examination Block B

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0241-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>M. Akveld, G.-I. Ionita</td>
</tr>
</tbody>
</table>

- Mathematical tools for the engineer
- Mathematical formulation of technical and scientific problems.
- Complex numbers.
- Calculus functions of one variable with applications. Simple Mathematical models in engineering.

- Wird auf der Vorlesungshomepage zu Verfügung gestellt.

- https://people.math.ethz.ch/~stammb/analysisskript.html
Second and Third Year Compulsory Courses

Courses of Examination Blocks

Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0243-00L</td>
<td>Analysis III</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>M. Akka Ginosar</td>
</tr>
</tbody>
</table>

Abstract
We will model and solve scientific problems with partial differential equations. Differential equations which are important in applications will be classified and solved. Elliptic, parabolic and hyperbolic differential equations will be treated. The following mathematical tools will be introduced: Laplace and Fourier transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Learning to model scientific problems using partial differential equations and developing a good command of the mathematical methods that can be applied to them. Knowing the formulation of important problems in science and engineering with a view toward civil engineering (when possible). Understanding the properties of the different types of partial differential equations arising in science and in engineering.

Content
Classification of partial differential equations
Study of the Heat equation general diffusion/parabolic problems using the following tools through Separation of variables as an introduction to Fourier Series.
Systematic treatment of the complex and real Fourier Series
Study of the wave equation and general hyperbolic problems using Fourier Series, D'Alembert solution and the method of characteristics.
Laplace transform and its uses to differential equations
Study of the Laplace equation and general elliptic problems using similar tools and generalizations of Fourier series.
Application of Laplace transform for beam theory will be discussed.

Lecture notes
Lecture notes will be provided

Literature
large part of the material follow certain chapters of the following first two books quite closely.

The course material is taken from the following sources:
Stanley J. Farlow - Partial Differential Equations for Scientists and Engineers
G. Felder: Partielle Differenzialgleichungen.
https://people.math.ethz.ch/~felder/PDG/

Prerequisites / notice
Analysis I and II, insbesondere, gewöhnliche Differentialgleichungen.

402-0023-01L Physics O 7 credits 5V+2U J. Faist

Abstract
This course gives an overview of important concepts in classical dynamics, thermodynamics, magnetism, atomic physics, and special relativity. Emphasis is placed on demonstrating key phenomena using experiments, and in developing skills for quantitative problem solving.

Objective
The goal of this course is to make students able to explain and apply the basic principles and methodology of physics to problems of interest in modern science and engineering. An important component of this is learning how to solve new, complex problems by breaking them down into parts and applying simplifications. A secondary goal is to provide to students an overview of important subjects in both classical and modern physics.

Content
Electrodynamics, Thermodynamics, Quantum physics, Waves and Oscillations, special relativity

Lecture notes
Lecture notes and exercise sheets will be distributed via Moodle

Literature
Compartiments

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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**101-0203-01L**  
**Hydraulics I**  
**O**  
5 credits  
3V+1U  
R. Stocker

**Abstract**
The course teaches the basics of hydromechanics, relevant for civil and environmental engineers.

**Objective**
- Understanding properties of water, hydrostatics, stability of floating bodies, continuity, Euler equation of motion, Navier-Stokes equations, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids vs. real fluids, boundary layer, pipe flow, open channel flow, flow measurements, demonstration experiments in the lecture hall.

**Content**
- Properties of water, hydrostatics, stability of floating bodies, continuity, Euler equation of motion, Navier-Stokes equations, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids vs. real fluids, boundary layer, pipe flow, open channel flow, flow measurements, demonstration experiments in the lecture hall.

**Lecture notes**
Script and collection of previous problems

**Literature**
Bollrich, Technische Hydromechanik 1, Verlag Bauwesen, Berlin

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**101-0113-00L**  
**Theory of Structures I**  
**O**  
5 credits  
3V+2U  
B. Sudret

**Abstract**
Introduction to structural mechanics, statically determinate beams and frame structures, trusses, stresses and deformations, statically indeterminate beams and frame structures (force method)

**Objective**
- Understanding the response of elastic beam and frame structures
- Ability to correctly apply the equilibrium conditions
- Understanding the basics of continuum mechanics
- Computation of stresses and deformations of elastic structures
- Ability to apply the force (flexibility) method for statically indeterminate structures

**Content**
- Equilibrium, reactions, static determinacy
- Internal forces (normal and shear forces, moments)
- Arches and cables
- Elastic trusses
- Influence lines
- Basics of continuum mechanics
- Stresses in elastic beams
- Deformations in Euler-Bernoulli and Timoshenko beams
- Energy theorems
- Statically indeterminate systems (Force method)

**Lecture notes**
Bruno Sudret, “Einführung in die Baustatik” (2021)

**Literature**
* Bruno Sudret, “Baustatik - Eine Einführung”, Springer Vieweg


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**151-0503-00L**  
**Mechanics III**  
**O**  
6 credits  
4V+2U  
D. Kochmann

**Abstract**
Dynamics of particles, rigid bodies, and deformable bodies: Motion of a single particle, motion of systems of particles, 2D and 3D motion of rigid bodies, vibrations, waves.

**Objective**
This course enables students to apply the concepts and laws governing the kinematics and kinetics of particles, rigid bodies, and elastic bodies in order to identify, formulate, and solve dynamical engineering problems. Specifically, students will be able to describe, analyze, and predict the motion of particles and bodies in space over time and to relate their motion to the applied forces for applications in (not only) mechanical and civil engineering.
Content

Students of mechanical and civil engineering learn the fundamental concepts of the dynamics of mechanical systems. By studying the motion of a single particle, systems of particles, of rigid bodies, and of deformable bodies, we introduce essential concepts such as kinematics, kinetics, work and energy, equations of motion, and forces and torques. Further topics include the stability of equilibria and vibrations as well as an introduction to the dynamics of deformable bodies and waves in elastic rods. Throughout the course, application-oriented examples help students acquire a proficient background in engineering dynamics, further to learn and embrace problem-solving techniques for dynamical engineering problems, gain cross-disciplinary expertise (by linking concepts from, among others, mechanics, mathematics, and physics), and prepare students for advanced courses and work on engineering applications. The detailed syllabus includes:

1. Motion of a single particle: kinematics (trajectory, velocity, acceleration), forces and torques, constraints, active and reaction forces, balance of linear and angular momentum, work-energy balance, conservative systems, equations of motion.
2. Motion of systems of particles: internal and external forces, balance of linear and angular momentum, work-energy balance, rigid systems of particles, particle collisions, mass accretion/loss.
3. Motion of rigid bodies in 2D and 3D: kinematics (angular velocity, velocity and acceleration transfer, instantaneous center and axis of rotation), balance of linear and angular momentum, work-energy balance, angular momentum transport, inertial vs. moving reference frames, apparent forces, Euler equations.
5. Introduction to waves and vibrations of elastic bodies: local form of linear momentum balance, waves in slender elastic rods.

Lecture notes

Lecture notes (a complete scriptum) is available on Moodle. Students are encouraged to take their own notes during class.

Literature

Lecture notes (a complete scriptum) is available on Moodle. Further reading materials are suggested but not required for this class.

Prerequisites / notice

For students in the bachelor’s degree programme in mechanical engineering:
Precondition for this course unit are passed first year examination blocks A and B.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-6615-00L</td>
<td>Materials in Civil Engineering I</td>
<td>O</td>
<td>5</td>
<td>8G</td>
<td>R. J. Flatt, U. Angst, I. Burgert, D. Kammer, F. Wittel</td>
</tr>
</tbody>
</table>

Abstract


Objective


Die Studierenden erlernen in den Vorlesungen und in auf diese abgestimmten Laborübungen theoretische und praktische Kompetenzen für den werkstoffgerechten Einsatz und bewussten Umgang mit Baustoffen als wertvolle Ressourcen.
Content

Der Jahreskurs gliedert sich in 8 Module, die auf 2 Semester verteilt sind. Module umfassen Vorlesungen und dazugehörige Labore:

HS:

Modul 1: Physikalisches Verhalten von Materialien und ihre Charakterisierung:
L (3-4): Labore zu Bauphysik, zu Finite Elemente Methoden, bewertete Hausübung zu LCA und zur Analyse wissenschaftlicher Daten.

Modul 2: Zementöse Baustoffe:
L (5): Labore zu Betontechnologie, Mineralische Bindemittel, Stein als Baumaterial, Mauerwerk und Mikrostruktur unterschiedlicher Baustoffe.

Modul 3: Amorphe Werkstoffe:

Modul 4: Digitale Fabrikation:
V (2): Methoden der digitalen Fabrikation und additiven Fertigung.
E (1): Exkursion Emersive Design Lab / HIB

FS:

Modul 5: Metalle und Korrosion:
L (3): Labore zu metallischen Werkstoffen, Dauerhaftigkeit von Stahlbetonbauten, detektieren und orten der Korrosion und digitaler Fabrikation.

Modul 6: Holz und Holzwerkstoffe:
L (2): Labore zu Holzeigenschaften auf Makro- und Mikroskopischer Ebene.

Modul 7: Baustoffe im Computer:
V (3): Grundlagen der Materialsimulation, Mikromechanik und Fallstudien zu Materialsimulationen für Baustoffe

Modul 8: Repetitorien:

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered

Social Competencies

Communication fostered
Customer Orientation fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

Exam Block 3

Number Title Type ECTS Hours Lecturers
101-0315-00L Geotechnical Engineering O 5 credits 4G A. Puzrin

Abstract

The course explores the fundamental principles of Geomechanics and Geotechnical Engineering, with the following objectives:
- Recognition of the basic consequences of the ground construction;
- Understanding of the important fundamental concepts of Soil mechanics and Geotechnical Engineering;
- Independent analysis of the basic geotechnical problems.

Objective

The course explores the fundamental principles of Geomechanics and Geotechnical Engineering, with the following objectives:
- Recognition of the basic consequences of the ground construction;
- Understanding of the important fundamental concepts of Soil mechanics and Geotechnical Engineering;
- Independent analysis of the basic geotechnical problems.

Content

Overview of stability problems; Bearing capacity of shallow and deep foundations; Soil-foundation interaction; Analysis and design of shallow and deep foundations; Earth pressure on retaining structures; Analysis and design of retaining walls; Excavations: dewatering, analysis and design; Soil improvement; Safety considerations.

Lecture notes

Examples

Literature


## Public Transport and Railways

### Objective

Teaches the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.

Teaches students to recognize the interactions between the infrastructure design and the production processes, and various performance criteria based on various perspective and stakeholders.

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate different choices of technologies to suitable cases; optimize the use of resources in public transport.

### Content

Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings

Vehicles: Classification, design and suitability for different goals

Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.

Operations: Passenger/Supply requirements for line operations; timetabling, measures of realized operations, capacity

### Literature

- Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

### Notice

- Slides, in English, are made available some days before each lecture.

### Prerequisites

- The content of steel structures I is a prerequisite

---

## Steel Structures II

### Objective


Fatigue resistance and safe life assessment. Detailing, drafting, fabrication and erection, cost estimation.

Students will expand the knowledge acquired during "Steel Structures I" and learn how to apply these skills to the design of more complex building and bridge steel and composite structures. They will acquire the fundamental background for the phenomena of plate buckling and fatigue and learn how to apply it to practical design tasks. In addition, students will learn to appreciate the importance of questions of detailing, fabrication, erection and cost calculation for the effective design of steel and composite structures.

After completion of the year-long course in Steel Structures I-II, students will have at their disposal a wide and detailed set of skills concerning the modern practice for steel and composite structures design and have a deep understanding of its theoretical & scientific background. The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

### Content

The lecture Steel Structures II complements the knowledge acquired in part 1 by providing students with additional theoretical and practical knowledge, e.g. on the design of steel and composite structures against fatigue, plate buckling, as well as on the structural modelling and analysis of more complex building and bridge structures. These more theoretical topics will be exemplified and illustrated by applications to real problems in the design of bridges and multi-storey building structures. Finally, the course will provide detailed insight into aspects pertaining to structural detailing, fabrication, erection and cost estimation for constructional steelwork.

Content overview:

- Structural forms, analysis techniques and modelling of multi-storey buildings and bridges.
- Structural analysis (deformations, internal forces, stresses and strains) in steel-concrete composite girders considering the effects of creep, shrinkage and shear deformations.
- Elastic and plastic longitudinal shear transfer mechanisms and effects
- Plate buckling of unstiffened and stiffened panels
- Fatigue resistance and safe life assessment: phenomenon and design approaches
- Special topics of steel connection design
- Detailing, drafting, fabrication and erection, cost determination in constructional steelwork

### Literature

- J.-P. Lebet, M. Hirt: Steel Bridges, Conceptual and Structural Design of Steel and Steel-Concrete Composite Bridges, EPFL Press
- Stahlbautenkalender (various editions), Ernst & Sohn, Berlin
- Detailling, drafting, fabrication and erection, cost calculation for the effective design of steel and composite structures.

### Notice

- The content of steel structures I is a prerequisite

---

## Method-specific Competencies

### Analytical Competencies

- Fostered

### Decision-making

- Fostered

### Media and Digital Technologies

- Fostered

### Problem-solving

- Assessed

### Project Management

- Fostered

### Social Competencies

### Communication

- Fostered

### Cooperation and Teamwork

- Fostered

### Customer Orientation

- Fostered

### Leadership and Responsibility

- Fostered

### Self-presentation and Social Influence

- Fostered

### Sensitivity to Diversity

- Fostered

### Negotiation

- Fostered

### Personal Competencies

### Adaptability and Flexibility

- Fostered

### Creative Thinking

- Assessed

### Critical Thinking

- Assessed

### Integrity and Work Ethics

- Fostered

### Self-awareness and Self-reflection

- Fostered

### Self-direction and Self-management

- Fostered

### Competencies

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**Data: 02.07.2024 12:39**

**Autumn Semester 2024**

**Page 171 of 2667**
The world’s growing population, changing demographics, and changing climate pose formidable challenges to humanity’s ability to live sustainably. Ensuring that humanity can live sustainably requires accommodating Earth’s growing and changing population through the provision and operation of a sustainable and resilient built environment. This requires ensuring excellent decision-making as to how the built environment is constructed and modified.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e., ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions in complex systems.

More specifically upon completion of the course, you will have gained insight into:
- how to structure the large amount of information that is often associated with attempting to modify complex systems
- how to set goals and define constraints in the engineering of complex systems
- how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking
- how to compare multiple possible solutions over time with differences in the temporal distribution of costs and benefits and uncertainty as to what might happen in the future
- how to assess values of benefits to stakeholders that are not in monetary units
- how to assess whether it is worth obtaining more information in determining optimal solution
- how to take a step back from the numbers and qualitatively evaluate the possible solutions in light of the bigger picture
- the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.

The lectures are structured as follows:

1. Introduction – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms. A high-level overview of the main principles of System Engineering. The expectations of your efforts throughout the semester.
2. Situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
3. Goals and constraints – How to set goals and constraints to identify the best solutions as clearly as possible.
4. Generation of possible solutions – How to generate possible solutions to problems, considering multiple stakeholders.
5. The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, weighting, and expected value.
6. The idea behind the supply and demand curves and revealed preference methods.
7. The concept of equivalence, including the time value of money, interest, life times and terminal values.
8. The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Internal rates of return.
9. How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.
10. Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. Linear programming and the simplex method.
11. How sensitivity analysis is conducted using linear programming.
12. How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.
13. How to set up and solve problems when there are multiple objectives.

The course uses a combination of qualitative and quantitative approaches.

Lecture notes
- The lecture materials consist of a script, the slides, example calculations in Excel, Moodle quizzes, and excercises.
- The lecture materials will be distributed via Moodle before each lecture.

Literature
Appropriate literature in addition to the lecture materials will be handed out when required via Moodle.
Structural Concrete I

Contents: Introduction, historical development of structural concrete, materials and material behaviour (cement, concrete, reinforcing steel, prestressing steel), linear members (axial force, flexure and axial force, compression members and columns, shear, bending and shear, torsion and combined actions), strut-and-tie models and simple stress fields, detailing, basic aspects of membrane elements.

Knowledge of the materials concrete and reinforcing steel and understanding their interaction;
Understanding the response of typical structural members;
Knowledge of elementary models and ability to apply them to practical problems;
Ability to correctly dimension and detail simple structures.

Lecture notes
The lecture notes as well as the lecture presentations and handouts may be downloaded from the website of the Chair of Hydrology and Water Resources Management.

Prerequisites / notice
Knowledge of statistics is a prerequisite. The required theoretical background, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows:
- Elementary data processing; hydrological measurements and data, data visualisation (graphical representation and numerical parameters).
- Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.

Self-direction and Self-management

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Adaptability and Flexibility

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Hydrology

The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the rainfall-runoff transformation, thereby including flood analysis.

Evaporation and evapotranspiration: processes, measurement and estimation, potential and actual evapotranspiration, energy balance method, empirical methods.

Infiltration: measurement, Horton’s equation, empirical and conceptual models, phi-index and percentage method, SCS-CN method.

Surface runoff and subsurface flow: Hortonian and Dunnian surface runoff, streamflow measurement, streamflow regimes, annual hydrograph, flood hydrograph analysis – baseflow separation, flow duration curve.

Basin characteristics: morphology, topographic and phreatic divide, hypsometric curve, slope, drainage density.

Rainfall-runoff models (R-R): rationale, linear model of rainfall-runoff transformation, concept of the instantaneous unit hydrograph (IUH), linear reservoir, Nash model.

Flood estimation methods: flood frequency analysis, deterministic methods, probabilistic methods (e.g. statistical regionalisation, indirect R-R methods for flood estimation, rational method).

Erosion and sediment transport: watershed scale erosion, soil erosion by water, estimation of surface erosion, sediment transport.

Snow (and ice) hydrology: snow characteristic variables and measurements, estimation of snowmelt processes by the energy budget equation and conceptual melt models (temperature index method and degree-day method), snowmelt runoff.

Self-presentation and Social Influence

Interception: measurement and estimation.

Knowledge of the hydrological cycle: global water resources, water balance, space and time scales of hydrological processes.

P. Burlando

ECTS
5 credits
3 credits
2G

W. Kaufmann

Autumn Semester 2024
Conceptual Design/Project Work

Number Title Type ECTS Hours Lecturers
101-0007-01L Project Work Conceptual Design O 3 credits 5S F. Ortiz Quintana

Abstract
A structure to be designed serves as a mean to practice the holistic approach of conceptual design by working in parallel and iteratively on different levels of detailing. Both, requirements and scope of action, are identified by the students and serve as basis for a solution. The task group organizes itself to solve complex tasks.

Objective
The project work conceptual design conveys a first insight into the holistic approach to cope with typical tasks of civil engineering and introduces professional techniques of civil engineering to students. A further aim is to consolidate the knowledge gained so far in bachelor courses, to link different domains and to fill gaps with respect to work techniques. The students analyse the inventory, formulate design requirements and boundary conditions, elaborate approaches and proposals for solutions, dimension some exemplary structural elements, practise detailing and document their work by different media.

Content
Topics:
- Basics of graphic representation
- Acceptance of service
- Analysis of third-party documents
- Site survey
- Conceptual design
- Service criteria agreement
- Technical specification
- Connections
- Structural analysis
- Quantities and costs
- Models

Methodology:
- Excursion with mission
- Lectures
- Autonomous work
- Role playing
- Presentations
- Deliveries
- Final presentation
- Exhibition

Bachelor’s Thesis

Number Title Type ECTS Hours Lecturers
101-0006-10L Bachelor’s Thesis O 8 credits 17D Supervisors

Abstract
The Bachelor Programme concludes with the Bachelor Thesis. This project is supervised by a professor. Writing up the Bachelor Thesis encourages students to show independence and to produce structured work. The contents base upon the fundamentals of the Bachelor Programme. Students can choose from different subjects and tasks. The thesis consists of both a written report and an oral presentation.

Science in Perspective

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

Language Courses

see Science in Perspective: Language Courses ETH/UZH
## Civil Engineering Bachelor - Key for Type

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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
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## Key for Hours

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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Civil Engineering Master

1. Semester

Seminar Work

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<td>Project Management for Construction Projects</td>
<td>O</td>
<td>4</td>
<td>3S</td>
<td>B. Hofer</td>
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</table>

Abstract
This course is designed to lay down the foundation of the different concepts, techniques, and tools for successful project management of construction projects.

Objective
The goal is that at the end of this course students should have a good understanding of the different project management knowledge areas, the phases required for successful project management, and the role of a project manager. To demonstrate this, students will work in groups in different case studies to apply the concepts, tools and techniques presented in the class.

Two 3 to 4 hours sessions towards the end of the lecture series will introduce a practical project to allow the teams to demonstrate the tools and techniques learned during the semester.

The course will have a final quiz that will be graded.

The course will be supported by several external lecturers from the construction industry and demonstrations of real-life case studies.

Content
The main content of the course is summarized in the following topics:

- Introduction, project and organization structures
- Project scheduling
- Resource management
- Risk management
- Project estimating and budgeting
- Project financing and Public-Private Partnerships (PPP)
- Construction Process management and controlling
- Sustainability management
- Reporting and Communication
- Interpersonal skills and leadership in Construction projects
- Advanced Topics in Construction Project management (BIM / 5D planning, Ki)
- Project Evaluation and Closure

Lecture notes
The slides for the class will be available for download from Moodle at least one day before each class. Copies of all necessary documents will be distributed at appropriate times.

Literature
Relevant readings will be recommended throughout the course (and made available to the students via Moodle).

Prerequisites / notice
The students will be randomly assigned to teams. Students will be graded as a team based on the final Project proposal with the in-class oral presentation as well as a final exam (50% exam and 50% project). Homework will not be graded but your final report and presentation will consist mostly of your homework assignments consolidated and put in a report and presentation format.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered
Decision-making assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

Major Courses

Major in Construction and Maintenance Management

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<td>151-8011-00L</td>
<td>Building Physics: Theory and Applications</td>
<td>W</td>
<td>4</td>
<td>3V+1U</td>
<td>A. Kubilay, X. Zhou, L. Fei, A. Rubin</td>
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Abstract
Enrolment after agreement with the lecturer only.
Principles of heat and mass transport, hygro-thermal performance, durability of the building envelope and interaction with indoor and outdoor climates, applications.

Objective
The students will acquire in the following fields:
- Indoor and outdoor climate and driving forces.
- Hygrothermal properties of building materials.
- Building envelope solutions and their construction.
- Hygrothermal performance and durability.

Content
Handouts, supporting material and exercises are provided online via Moodle.
Priority will be given to students in Integrated Building Systems Master (MIBS).
Please send an email to the main lecturer, if you are not a MIBS student.

Competencies
Subject-specific Competencies
Concepts and Theories assessed

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<td>Design and Building Process MIBS</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. Paulus, S. Menz</td>
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</table>
Design and Building Process MIBS is a brief manual for prospective architects and engineers covering the competences and the responsibilities of all involved parties through the design and building process. Lectures on six compact aspects gaining importance in a increasingly specialised, complex and international surrounding.

**Objective**

Participants will come to understand how they can best navigate the design and building process, especially in relation to understanding their profession, gaining a thorough knowledge of rules and regulations, as well as understanding how involved parties’ minds work. They will also have the opportunity to investigate ways in which they can relate to, understand, and best respond to their clients’ wants and needs. Finally, course participants will come to appreciate the various tools and instruments, which are available to them when implementing their projects. The course will guide the participants, bringing the individual pieces of knowledge into a superordinate relationship.

**Content**

Design and Building Process MIBS is a brief manual for prospective architects and engineers covering the competences and the responsibilities of involved parties through the design and building process. Three compact chapters regarding the established building culture are gaining importance in an increasingly specialised, complex and international surrounding. Lectures on the topics of competence, organisation, agility, monitoring, interest, and the environment will guide the participants, bringing the individual pieces of knowledge into a superordinate relationship. The course introduces the key figures, depicts the criteria of the project and highlights the proved services of the consultants. In addition to discussing the basics, the terminologies and the tendencies, the lecture units will refer to the studios as well as the practice: Teaching-based workshops will compliment and deepen the understanding of the three selected aspects of profession, methodology, and environment. The course is presented as a moderated seminar to allow students the opportunity for individual input: active collaboration between the students and their tutor therefore required.

**Literature**

https://map.arch.ethz.ch

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**101-0427-01L Public Transport Design and Operations**

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<th>W</th>
<th>6 credits</th>
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<th>F. Corman</th>
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**Abstract**

This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system. Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view. At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

**General structure:**

- general introduction of transport, modes, technologies,
- system design and line planning for different situations,
- mathematical models for design and line planning
- timetabling and tactical planning, and related mathematical approaches
- operations, and quantitative support to operational problems,
- evaluation of public transport systems.

**Content**

Basics for line transport systems and networks

- Passenger/Supply requirements for line operations
- Objectives of system and network planning, from different perspectives and users, design dilemmas
- Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Planning process, from demand evaluation to line planning to timetables to operations
- Matching demand and modes
- Line planning techniques
- Timetabling principles

Allocation of resources
- Management of operations
- Measures of realized operations
- Improvements of existing services

Lecture notes

Lecture slides are provided.
Infrastructure management is the process that ensures infrastructure provides desired service over time. This course provides an overview of the process and insight into some of the most important parts, i.e., defining service, justifying interventions, monitoring the infrastructure system, and ensuring a well-functioning infrastructure management organisation.

The objective of this course is to provide an overview of the infrastructure management process. The high-level process can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. This process can be used to help improve the specific infrastructure management processes in the organisations.

More specifically upon completion of the course, students had their first experience with:

- defining the service to be provided by infrastructure,
- developing and evaluating asset strategies, and converting them into programs / project portfolios
- establishing a monitoring program for an infrastructure system, and
- establishing basic rules and principles to ensure an infrastructure management organisation is running well.

The weekly lectures are structured as follows:

1. Introduction: An introduction to infrastructure management and the project.
2. Service: Determination of what service you are trying to provide with an infrastructure network is important in justifying the interventions you think are required and ensuring that investment decisions are aligned throughout an infrastructure management organisation. This lecture introduces the concept of serve and connects it to measurable indicators.
3. Help session 1: This session provides time for your group to ask questions as you define the service you want your infrastructure network to provide
4. Presentation 1: 4 groups will present their ideas on how they want their networks to provide service
5. Interventions: Justifying the interventions you want to execute to ensure you continue to provide the defined service requires you to model deterioration, determining economically justifiable strategies and explain which interventions will be postponed if you can't do all you would like. This lecture is focused on explaining the main principles behind each of these concepts.
6. Help session 2: This session provides time for your group to ask questions as you justify the interventions you want to execute on your infrastructure network over time and explain what you will postpone if you cannot do all of them.
7. Presentation 2: 4 groups will present how they have justified interventions and how they have selected the ones they would like to postpone if required
8. Monitoring: To ensure you the infrastructure network is providing what you expect you need to monitor its performance and how projects are being done. This lecture is focused on the principles to ensure a monitoring system is set up that ensure that the infrastructure system is providing the expected service.
9. Help session 3: This session provides time for your group to ask questions on how to establish the monitoring systems for your infrastructure networks.
10. Presentation 3: 4 groups will present how they intended to monitor their systems and projects.
11. Organisation: Managing infrastructure only works well with great teams of people with great processes. This lecture focuses on the principles of ensuring a well-functioning organisation and well-functioning processes.
12. Help session 4: This session provides time for your group to ask questions on how to ensure well-functioning organisations and well-functioning processes.
13. Presentation 4: 4 groups will present how they intended to ensure well-functioning organisations and well-functioning processes.

- The lecture materials consist of handouts and the slides.
- The lecture materials will be distributed via Moodle by the beginning of each lecture.
- The questions to be discussed in the discussion session will be distributed by the end of the day on the Monday before the discussion session.
Appropriate literature will be handed out when required via Moodle.

This course has no prerequisites.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
<td>Decision-making</td>
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<td>Project Management</td>
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Abstract

In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. This decarbonization strategy is additional to Sustainable Development goals formulated the same year by the UN general assembly.

Objective

At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmetal aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content

The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development and beyond

Methods

- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification
- Method 4: Material Flow Analysis

Main issues:

- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

Literature

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.
## Major in Geotechnical Engineering

### 101-0317-00L Tunnelling I

**Abstract**

Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.

**Objective**

Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.

**Content**

- Numerical analysis methods in tunnelling.
- Conventional excavation methods (full face, top heading and bench, side drift method, ...)
- Auxiliary measures:
  - Injections
  - Jet grouting
  - Ground freezing
  - Drainage
  - Forepoling
  - Face reinforcement

**Lecture notes**

Autographieblätter

**Literature**

Empfehlungen

This course will continue to be offered in German up to and including HS24.

### 101-0357-00L Theoretical and Experimental Soil Mechanics

**Prerequisites:** Mechanics I, II and III.

**Abstract**

Overview of soil behaviour

- Discussion of general gaps between basic theory and soil response
- Stress paths in practice & in laboratory tests
- Triaxial tests: consolidation & shear, drained & undrained response
- Plasticity theory & Critical State Soil Mechanics, Cam Clay

**Objective**

1. Extend knowledge of theoretical approaches that can be used to describe soil behaviour.
2. Offer the opportunity to perform hands on element tests required for constitutive model calibration.
3. Enable students to select an appropriate constitutive model and calibrate it using element test performed in the lab.
4. Enable students to carry out FE analyses for realistic geotechnical applications.

**Content**

- Overview of soil behaviour
- Discussion of general gaps between basic theory and soil response
- Stress paths in practice & in laboratory tests
- Triaxial & direct shear tests: consolidation & shear, drained & undrained response
- Plasticity theory & Critical State Soil Mechanics, Cam Clay

**Lecture notes**

Printed script with web support

**Literature**

https://moodle-app2.let.ethz.ch/

**Prerequisites / notice**

Pre-requisites: Fundamental knowledge of solid and soil mechanics.

The theoretical part of the course will be covered by problem-based lectures. The experimental part will be covered by hands-on element tests performed by the students in the laboratory. These experimental results will be instrumental in the calibration of advanced soil constitutive models.

The connection between the experimental and theoretical parts of the course will be facilitated by means of numerical investigations (i.e., FE analyses), including the selection and calibration of relevant constitutive models. The numerical investigations shall be documented by the students in a final report.

Laboratory equipment will be available for 60 students. Students registered for the Geotechnics Specialty in Masters will be given priority as follows: (1) 2nd year students; (2) 1st year students, (3) doctoral students taking the class for their qualifying exam; Further students will be admitted on a first-come-first-served basis.
Abstract
This lecture deals with the practical application of the knowledge gained in the fundamental lectures from the Bachelor degree. The basics of planning and design of geotechnical structures will be taught for the main topics geotechnical engineers are faced to in practice.

Objective
Transfer of the fundamental knowledge taught in the Bachelor degree to practical application.
Ability to plan and design geotechnical structures based on the state of the art.

Content
- Introduction to Swisscode SIA
- Foundations and settlements
- Pile foundations
- Excavations
- Slopes
- Soil nailing
- Reinforced geosystems
- Ground improvement
- River levees

Lecture notes
Script in the form of chapters and powerpoint overheads with web support (moodle-app2.let.ethz.ch)
Exercises

Literature
Relevant literature will be stated during the lectures

Prerequisites / notice
Pre-condition: Successful examinations (pass) in the geotechnical studies (soil mechanics and ground engineering, each 5 credits) in the Bachelor degree of Civil Engineering (ETH), or equivalent for new students.
The lecture contains at least one presentation from practice.

Competencies
- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
  - Decision-making fostered
- Social Competencies
  - Communication fostered
  - Cooperation and Teamwork fostered
  - Customer Orientation fostered
  - Leadership and Responsibility fostered
  - Self-presentation and Social Influence fostered
  - Sensitivity to Diversity fostered
  - Negotiation fostered
- Personal Competencies
  - Adaptability and Flexibility fostered
  - Creative Thinking assessed
  - Critical Thinking assessed
  - Integrity and Work Ethics fostered
  - Self-awareness and Self-reflection fostered
  - Self-direction and Self-management fostered

101-0369-00L Forensic Geotechnical Engineering
Prerequisites: successful participation in "Geotechnical Engineering" (101-0315-00L) or an equivalent course.

Abstract
In this course selected famous geotechnical failures are investigated with the following purpose: (a) to deepen understanding of the geotechnical risks and possible solutions; (b) to practice design and analysis methods; (c) to learn the techniques for investigation of failures; (d) to learn the techniques for mitigation of the failure damage.

Objective
In this course selected famous geotechnical failures are investigated with the following purpose: (a) to deepen understanding of the geotechnical risks and possible solutions; (b) to practice design and analysis methods; (c) to learn the techniques for investigation of failures; (d) to learn the techniques for mitigation of the failure damage.

Content
- Failure due to the loading history
- Failure due to excessive settlements
- Failure due to the leaning instability
- Bearing capacity failure
- Excavation failure
- Failure in the creeping landslides
- Failure evolution in submarine landslides
- Construction in the landslide influence zone
- Delayed failure in snow avalanches

Lecture notes
Lecture notes
Exercises

Literature

Prerequisites / notice
The course is given in the first MSc semester.
Prerequisite: Basic knowledge in Geotechnical Engineering (Course content of "Grundbau" or similar lecture).
After passing this course students will be able to:

**Concepts and Theories**
- assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**Compeencies**

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<tr>
<td><strong>101-0328-00L</strong> Granular Mechanics</td>
<td>4 credits</td>
<td>4G</td>
<td>J. Gaume</td>
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**Abstract**
This course aims to provide a basic understanding of the mechanics and rheology of granular matter. It includes fundamental concepts as well as recent progress in research with main focus on related engineering and natural hazards applications. Small experiments are performed in class to illustrate important processes and state-of-the-art numerical modeling tools are introduced and used.

**Objective**
Granular materials have the ability to sustain stresses like a solid of flow like a fluid depending on the applied solicitation and boundary conditions. This course targets civil, geotechnical and mechanical engineering students, who are interested in discovering the fascinating and sometimes surprising world of granular media, the second most used material in industry and in learning novel modeling approaches. After this class, the students should know how to describe inter-particle interactions at the grain scale, the statics of granular materials, the transition towards fluid states through classical frictional plastic laws and the rheology of granular flows. Furthermore, the students should know the basics of the Discrete Element Method (DEM), its advantage and limitations and should be able to use a commercial software for different types of application.

**Content**
This course covers grain-scale interactions, statics and rheology of granular materials based on a mix between classical lectures, on-board developments, presentation of small experiments, analytical and numerical exercises. We present the domains of application of granular mechanics through examples taken from the industry or research. In addition, the Discrete Element Method (DEM) together with state-of-the-art contact models will be presented and used to simulate standard tests such as the granular column collapse, shear flows but also more complex industrial or geophysical problems. Calibration of model parameters based on laboratory experiments will be discussed. The course will not cover aspects related to granular gazes and kinetic theory.

**Lecture notes**
Lecture slides and lecture notes will be provided on Moodle.

**Literature**
Books:
1. Granular Media: Between Fluid and Solid by Bruno Andreotti, Olivier Pouliquen, and Yoël Forterre
2. Particulate Discrete Element Modelling: A Geomechanics Perspective by Catherine O’Sullivan

**Prerequisites / notice**
Basic knowledge of physics, mechanics and soil mechanics is required.

**Major in Structural Engineering**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>101-0117-00L Theory of Structures III</td>
<td>O</td>
<td>4 credits</td>
<td>2G</td>
<td>B. Stojadinovic</td>
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**Abstract**
This course focuses on the axial, shear, bending and torsion load-deformation response of continuous elastic prismatic structural elements such as rods, beams, shear walls, frames, arches, cables and rings, and structures that contain such elements. Additional special topics may be addressed time-permitting.

**Objective**
After passing this course students will be able to:
1. Explain the equilibrium of continuous structural elements.
2. Formulate mechanical models of continuous prismatic structural elements.
3. Analyze the axial, shear, bending and torsion load-deformation response of prismatic structural elements and structures assembled using these elements.
4. Determine the state of forces and deformations in rods, beams, frame structures, arches, cables and rings under combined mechanical and thermal loading.
5. Use the theory of continuous structures to design structures and understand the basis for structural design code provisions.

**Content**
This is the third course in the ETH series on theory of structures. Building on the material covered in previous courses, this course focuses on the axial, shear, bending and torsion load-deformation response of continuous elastic prismatic structural elements such as rods, beams, shear walls, frames, arches, cables and rings, and structures assembled using such elements. Additional special topics, such as the behavior of inelastic prismatic structural elements or the behavior of planar structural elements and structures may be addressed if time permits. The course provides the theoretical background and engineering guidelines for practical structural analysis of modern structures.

**Lecture notes**
Electronic copies of the learning material will be managed using Moodle. The learning material includes the lecture presentations, additional reading, and exercise problems and solutions. Lectures are streamed live and recorded on the ETH Video Portal.
Literature

Prerequisites / notice
Working knowledge of theory of structures, as covered in ETH course Theory of Structures I (Baustatik I) and Theory of Structures II (Baustatik II), and ability to solve ordinary differential equations. Basic knowledge of structural design of reinforced concrete, steel or wood structures. Familiarity with structural analysis computer software and computer tools such as Python, Matlab, Mathematica, Mathcad or Excel.

Competencies

101-0127-00L Advanced Structural Concrete

Objectives
Within this course, the students are able to:
- deepen their understanding of structural concrete models and apply them to general design problems, including the assessment of existing structures.
- enhance their knowledge about the load-deformation response of reinforced and prestressed concrete structures.
- identify and assess the limits of applicability of limit analysis methods.
- recognise the assumptions of models suitable for computer-aided structural design and use in a critical way structural concrete design software.
- evaluate the long-term behaviour and the behaviour under fire conditions of concrete structures.
- assess the behaviour of fibre reinforced concrete structures.

Content
Fundamentals (structural analysis, theorems of limit analysis, applicability of limit analysis methods); walls and beams (stress fields and strut-and-tie models, compatibility and deformation capacity, membrane elements with yield conditions and load-deformation behaviour, computer-aided structural design); slabs (equilibrium solutions, yield conditions, shear and punching shear, sustainability); long term effects; steel fibre reinforced concrete (mechanical behaviour, applications); fire behaviour.

Lecture notes
Lecture notes see: http://www.concrete.ethz.ch

Literature

Prerequisites / notice
Students are assumed to be proficient in the material taught in the following courses offered in the BSc in Civil Engineering at ETH Zurich (or have acquired equivalent knowledge elsewhere):
- Theory of structures I-II
- Structural Concrete I-II (incl. prestressed concrete)

Competencies

101-0137-00L Steel Structures III: Advanced Steel and Composite Structures

Abstract
Expand the theoretical background and practical knowledge in the design of steel and composite structures. Special composite construction and detailing: partial connection, serviceability. Fire design. Cold-formed steel design. Crane girders; masts; tanks & silos. Structural glazing and lightweight cable-supported structures.
Objective
In Steel Structures III, students will deepen and expand their theoretical background and practical knowledge of the design and construction of steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. Students will learn how to solve complex structural engineering tasks in larger building projects, e.g. through the use and correct design of large-span slim-floor girders and ultra-slimer composite columns, or the use of glazing and cable structures as principal load-carrying components. They learn how steel structures behave under fire conditions and how they can be protected and designed accordingly. Finally, students learn about the fundamental aspects governing the design of specialty steel structures, such as thin-walled cold-formed sections, crane girders, masts and storage tanks.

The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

Content
Steel Structures III provides in-depth theoretical background and practical knowledge on advanced design topics in steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. The course discusses the use and design of large-span slim-floor girders and ultra-slimer composite columns, as well as the use of glazing and cable structures as principal load-carrying components. The design of steel structures under elevated temperatures (fire conditions) is treated, as well as special topics of design for serviceability. In addition, fundamental concepts of the design of cold-formed steel framed structures are discussed. Finally, the course will give an overview on the design of specialty steel structures, such as crane girders, masts and storage tanks.

Lecture notes
Slides and lecture notes. Worked examples. Handouts and formula collections.

Literature
Stahlbaukalender (various editions), Ernst + Sohn, Berlin

Prerequisites / notice
Prerequisites: Steel Structures I and II

<table>
<thead>
<tr>
<th>101-0187-00L</th>
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<tbody>
<tr>
<td>Structural Reliability and Risk Analysis</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.</td>
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<td>Content</td>
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<td>The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.</td>
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<tr>
<td>Lecture notes</td>
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<tr>
<td>Slides and lecture notes. Worked examples. Handouts and formula collections.</td>
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<tr>
<td>Literature</td>
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<tr>
<td>Prerequisites / notice</td>
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<tr>
<td>Basic course on probability theory and statistics</td>
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| 101-0157-01L |
| Structural Dynamics and Vibration Problems |
| Objective |
| Fundamentals of structural dynamics are presented. Computing the response of elastic single and multiple DOF structural systems subjected to harmonic, periodic, pulse, and impulse excitation is discussed. Practical solutions to vibration problems in flexible structures under diverse excitations are developed. |
| Content |
| After successful completion of this course the students will be able to: |
| 1. Explain the dynamic equilibrium of structures under dynamic loading. |
| 2. Use second-order differential equations to theoretically and numerically model the dynamic equilibrium of structural systems. |
| 3. Model structural systems using single-degree-of-freedom, or the use of glazing and cable structures as principal load-carrying components. |
| 4. Compute the dynamic response of structural system to harmonic, periodic, pulse, and impulse excitation using time-history and response-spectrum methods. |
| 5. Use dynamics of structures to identify the basis for structural design code provisions related to dynamic loading. |
| Lecture notes |
| The class will be taught mainly on the blackboard. Accompanying electronic material will be uploaded to ILIAS and available through myStudies. |

All the material can be found in Anil Chopra's comprehensive textbook given in the literature below.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 184 of 2667
Literature


Prerequisites / notice

Knowledge of the fundamentals in structural analysis, and in structural design of reinforced concrete, steel and/or wood structures is mandatory. Working knowledge of matrix algebra and ordinary differential equations is required. Familiarity with Matlab and with structural analysis computer software is desirable.

151-8015-00L Moisture Transport in Porous Media

Abstract

Moisture transport and related degradation processes in porous materials. Theory of moisture transport in porous materials. Experimental determination of moisture transport properties. Exercises on moisture transport properties determination:

- Liquid transport in cracked porous media, Drying of porous media, microclimate in urban street canyons.

Objective

- Basic knowledge of moisture transport and related degradation processes in porous materials.
- Knowledge of experimental determination of moisture transport properties.
- Application of knowledge to moisture transport in cracked materials, drying of porous materials and microclimate in urban street canyons.

Content

1. Introduction
   - Moisture damage: problem statement, durability
   - Applications: building materials, soil science, geoscience

2. Moisture transport: theory and application
   - Description of moisture transport
   - Determination of moisture transport properties
   - Exercises on moisture transport properties

3. Special topics
   - Liquid transport in cracked materials, Drying of porous materials, Microclimate in urban street canyons

Lecture notes

Handouts, supporting material and exercises are provided online via Moodle.

Literature

- All material is provided online via Moodle.
- Lecture notes
- Conceptual and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving
- Communication
- Cooperation and Teamwork
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

101-0167-01L Fibre Composite Materials in Structural Engineering

Abstract

- 1) Lamina and Lamine Theory
- 2) FRP Manufacturing and Testing Methods
- 3) Design and Application of Externally Bonded Reinforcement to Concrete, Timber, and metallic Structures
- 4) FRP Reinforced Concrete, All FRP Structures
- 5) Measurement Techniques and Structural Health Monitoring

Objective

At the end of the course, you shall be able to:

1) Design advanced FRP composites for your structures,
2) To consult owners and clients with necessray testing and SHM techniques for FRP structures,
3) Continue your education as a phd student in this field.

Content

- fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring techniques. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

Lecture notes

Power Point Presentations available online at www.empa.ch/abt303

Literature

3) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019

Prerequisites / notice

1) Laboratory Tours and Demonstrations: Empa Structural Engineering Laboratory including FRP Composites, Shape Memory Alloys, Timber Elements, Large Scale Testing of Structural Components
2) Working with Composite Materials in the Laboratory (application, testing, etc.)

101-0637-01L Timber Structures I

Abstract

- Timber Structures I

Objective

- Timber Structures I

Content

- Timber Structures I

Lecture notes

Power Point Presentations available online at www.empa.ch/abt303

Literature

1) Laboratory Tours and Demonstrations: Empa Structural Engineering Laboratory including FRP Composites, Shape Memory Alloys, Timber Elements, Large Scale Testing of Structural Components
2) Working with Composite Materials in the Laboratory (application, testing, etc.)
Major in Transport Systems

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>101-0427-01L</td>
<td>Public Transport Design and Operations</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>F. Corman</td>
</tr>
</tbody>
</table>

This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.

Objective
Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders.
The most relevant decision making problems in a planning tactical and operational point of view
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.
Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes are provided.

Literature
Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Traffic Engineering
O 6 credits 4G A. Kouvelas
Abstract Fundamentals of traffic flow theory and control.
Objective The objective of this course is to fully understand the fundamentals of traffic flow theory in order to effectively manage traffic operations. By the end of this course students should be able to apply basic techniques to model different aspects of urban and inter-urban traffic performance, including congestion.
Content Introduction to fundamentals of traffic flow theory and control. Includes understanding of traffic data collection and processing techniques, as well as data analysis, traffic modeling, and methodologies for traffic control.
Lecture notes The lecture notes and additional handouts will be provided during the lectures.
Prerequisites Verkehr III - Road Transport Systems 6th Sem. BSc (101-0415-00L)

Transport Planning Methods
W 6 credits 4G E. Heinen
Abstract The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.
Objective - Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

The exercises provide a framework for practical application of the learned theoretical concepts of spatial planning to real-life situations.

The course focuses on both theoretical concepts and practice-oriented approaches to gain knowledge and be equipped to address current issues in spatial planning and development. This is mirrored in the course’s structure made of both of lectures and exercises.

The lecture series introduces necessary key concepts and covers the following main topics:
- Drivers of spatial development, inward development, core tasks and current challenges for (spatial) planners.
- Interplay of formal and informal planning instruments across scales and actors.
- Differentiation urban typologies, their characteristics and challenges
- Types of spatial analysis and key figures
- Planning approaches and the (political) steering of spatial development.
- Types of processes and participation in spatial development.
- Approaches for planning complex urban situations
- Concepts for sustainable development

The exercises provide a framework for practical application of the learned theoretical concepts of spatial planning to real-life situations.
### Basics of Air Transport (Aviation I)

**Code:** 151-0227-00L  
**Title:** Basics of Air Transport (Aviation I)  
**Credits:** 4  
**Lecturer:** P. Wild

#### Abstract
In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation. The program is taught in English and we provide 11 different experts/lecturers.

#### Objective
The goal is to understand and explain basics, principles and contexts of the broader air transport industry. Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport. Ideal foundation for Aviation II - Management of Air Transport.

#### Content
Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

- Concept: This course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

- Content: Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Planning; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

- Technical visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

#### Literature
- Preparation materials & slides are provided prior to each class
- Literature will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)

#### Prerequisites / notice
The lecture is planned as class teaching.

### Railway Systems I

**Code:** 227-0523-00L  
**Title:** Railway Systems I  
**Credits:** 6  
**Lecturer:** M. Meyer

#### Abstract
Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance

#### Objective
- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators
The weekly lectures are structured as follows:

### Infrastructure Management 1: Process

**Assessed**

B. T. Adey

Critical Thinking

The objective of this course is to provide an overview of the infrastructure management process. The high-level process can be used as a framework to assess how well your infrastructure network is performing over time. This course provides an overview of the process and insight into some of the most important parts, i.e., defining service, justifying interventions, monitoring the infrastructure system, and ensuring a well-functioning organisation.

The course is designed to help you improve the specific infrastructure management processes in the organisations. The lectures are structured as follows:

1. **Introduction:** An introduction to infrastructure management and the project.
2. **Service:** Determination of what service you are trying to provide with an infrastructure network. This lecture introduces the concept of service and connects it to measurable indicators.
3. **Help session 1:** This session provides time for your group to ask questions as you define the service you want your infrastructure network to provide.
4. **Presentation 1:** 4 groups will present their ideas on how they want their networks to provide service.
5. **Interventions:** Justifying the interventions you want to execute to ensure you continue to provide the defined service requires you to model deterioration, determining economically justifiable strategies and explain which interventions will be postponed if you can't do all you would like. This lecture is focused on explaining the main principles behind each of these concepts.
6. **Help session 2:** This session provides time for your group to ask questions as you justify the interventions you want to execute on your infrastructure network over time and explain what you will postpone if you cannot do all of them.
7. **Presentation 2:** 4 groups will present how they have justified interventions and how they have selected the ones they would like to postpone if required.
8. **Monitoring:** To ensure you the infrastructure network is providing what you expect you need to monitor its performance and how projects are being done. This lecture is focused on the principles to ensure a monitoring system is set up that ensure that the infrastructure system is providing the expected service.
9. **Help session 3:** This session provides time for your group to ask questions on how to establish the monitoring systems for your infrastructure networks.
10. **Presentation 3:** 4 groups will present how they intended to ensure well-functioning organisations and well-functioning processes.
11. **Organisation:** Managing infrastructure only works well with great teams of people with great processes. This lecture focuses on the principles of ensuring a well-functioning organisation and well-functioning processes.
12. **Help session 4:** This session provides time for your group to ask questions on how to ensure well-functioning organisations and well-functioning processes.
13. **Presentation 4:** 4 groups will present how they intended to ensure well-functioning organisations and well-functioning processes.
Hydraulic structures and their functions within hydraulic systems are treated in this lecture. The basic concepts of their layout and design are fostered in this course.

### Literature

Appropriate literature will be handed out when required via Moodle.

This course has no prerequisites.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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**Urban Systems and Transportation**

This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

#### Objective

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.

#### Content

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

### Lecture notes

Course slides will be made available to students prior to each class.

### Literature

Course slides will be made available to students.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed

#### Social Competencies
- Communication: fostered

#### Personal Competencies
- Critical Thinking: fostered

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**Major in Hydraulic Engineering and Water Resources Management**

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<tr>
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<td>O</td>
<td>6</td>
<td>4G</td>
<td>R. Boes</td>
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*Information: Enrolment of Hydraulic Engineering II is not recommended without having attended Hydraulic Engineering (101-0206-00L) previously since Hydraulic Engineering II is strongly based on Hydraulic Engineering (101-0206-00L).*

### Abstract

Hydraulic structures and their functions within hydraulic systems are treated in this lecture. The basic concepts of their layout and design with regard to economy and safety are provided.

### Objective

Knowledge of hydraulic structures and their functions within hydraulic systems. Skills for the layout and design of hydraulic structures with regard to economy and safety.

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 191 of 2667
Weirs: Weir stability, gates, inflatable dams, appurtenant structures, fish up- and downstream passages.

Conduits: Design of headraces, pressure shafts, and penstocks, structural details and construction.

Hydropower plants: Powerhouse and turbine types, design, functionality, construction processes.

Dams: Types, appurtenant structures (river diversion, spillways, bottom and low-level outlets), dam type selection criteria, layout and design of gravity dams, buttress dams, arch dams, rockfill dams with central core or concrete face, reservoir sedimentation and sediment management, dam surveillance.

Artificial reservoirs: Purpose, layout, sealing, appurtenant structures, environmental aspects.

Economical aspects of hydraulic infrastructure

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Prerequisites / notice

Information: Because Hydraulic Engineering II is strongly based on Hydraulic Engineering (Wasserbau, 101-0206-00L) it is strongly recommended to have taken this course (101-0206-00L) or a similar one previously.

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<tr>
<th>Lecture notes</th>
<th>Slides from the lectures and programs used can be downloaded.</th>
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<tbody>
<tr>
<td>Literature</td>
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101-0258-00L

River Engineering

Abstract

The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

Objective

At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content

The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river rehabilitation project at the Alpine Rhine in Austria and Switzerland.

The lecture slides can be downloaded via Moodle.

Prerequisites / notice

Recommended lectures:
- Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Short practical exercises (voluntary) will be offered throughout the semester to improve the application of the learned subjects.
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

### Competencies

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### Abstract

Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapli-ETH, and learn about other similar models at larger scales. They apply Topkapli-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

### Literature

Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

### Prerequisites / notice

Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences). Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

### Competencies

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<tr>
<th>102-0468-10L</th>
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<td><strong>Watershed Modelling</strong></td>
<td><strong>Solving Partial Differential Equations in Parallel on GPUs</strong></td>
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### Content

- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).
Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites / notice
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

Competencies

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Major in Materials and Mechanics

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<tr>
<td>101-0677-00L</td>
<td>Concrete Technology</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>F. Nägele, G. Martinola, T. Wangler</td>
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Abstract
Opportunities and limitations of concrete technology, Commodities and leading edge specialties.

Objective
Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.

Content
- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- - specialty concretes such as: self compacting concrete, fiber reinforced concrete, fast setting concrete
- - the role of sustainability in concrete technology
- - new research in digital fabrication with concrete

Lecture notes
Slides provided for download.

Competencies

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151-8015-00L  Moisture Transport in Porous Media  W  3 credits  2G  J. Carmeliet, A. Kubilay, A. Rubin, D. A. Strebel

Abstract
Moisture transport and related degradation processes in porous materials Theory of moisture transport in porous materials Experimental determination of moisture transport properties Exercises on moisture transport properties determination: Selected topics Liquid transport in cracked porous media, Drying of porous media, microclimate in urban street canyons.

Objective
- Basic knowledge of moisture transport and related degradation processes in porous materials
- Knowledge of experimental determination of moisture transport properties
- Application of knowledge to moisture transport in cracked materials, drying of porous materials and microclimate in urban street canyons

Content
1. Introduction
   - Moisture damage: problem statement, durability
     - Applications: building materials, soil science, geoscience
2. Moisture transport: theory and application
   - Description of moisture transport
   - Determination of moisture transport properties
   - Exercises on moisture transport properties
3. Special topics
   - Liquid transport in cracked materials, Drying of porous materials, Microclimate in urban street canyons

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Literature
All material is provided online via Moodle.
101-0617-01L Advances in Building Materials

Abstract
The course on Advances in Building Materials provides an introductory overview of the needs and future of materials science in the building sector. Focus topics concern sustainability, durability, thermal insulation, coatings, sealants, adhesives, flame retardancy and the future perspective and developments of concrete and wood with regard to smart material development and ecological concerns.

Objective
In this course, the students will gain a broad overview of the use of materials in the building sector, with a particular focus on concrete and wood. Current limitations and in particular sustainability related challenges will be detailed with the objective of laying the grounds to discuss future developments anticipated in this field.

Content
This course for civil engineers lays the grounds in the specialization Materials and Mechanics and complements the second introductory course of the specialization on Numerical Mechanics of Materials. The course also addresses master students in Materials Science and other study programs interested in deepening their understanding of application-relevant properties of engineering materials and sustainability related challenges. The following topics are covered:

1. Material selection
2. Materials and sustainability 1
3. Materials and sustainability 2
4. Recyclability
5. Material science of wood durability
6. Material science of concrete durability
7. Foams in construction and thermal insulation
8. Sealants and adhesives in construction
9. Coatings
10. Flame retardants
11. Future of wood – 1
12. Future of wood – 2
13. Future of concrete – 1
14. Future of concrete – 2

Lecture notes
Handouts will be provided for each lecture.

101-0617-02L Computational Science Investigation for Material Mechanics

Abstract
Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various material models.

Objective
Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can often only be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

Content
1. Introduction to (numeric) forensic engineering
2. The nature of engineering problems (governing equations)
3. Numerical recipes for dealing with non-linear problems
4. Multi-field problems (HTM)
5. Creep and relaxation
6. On the nature of failure - Physics of damage and fracture
7. Cracks and growth in structures (LEFM and beyond)
8. Damage and fracture in heterogeneous materials
9. Mechanics of fatigue
10. Student -Project presentation

Lecture notes
Will be provided during the lecture via moodle.

Literature
Will be provided during the lecture.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Social Competencies
Communication assessed
Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

151-0353-00L Mechanics of Composite Materials

W 4 credits 2V+1U G. Pappas
Abstract
The courses treats aspects related to elastic behavior of unidirectional and multidirectional laminates, micromechanics, failure and damage analysis, analysis and design of composite structures. The focus is on laminated fiber-reinforced polymer composites.

Objective
The objective is to introduce the basic concept of composite materials and provide a thorough understanding of the mechanical response of such materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

Content
The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics & Homogenization
- Classical Laminate Theory (CLT)
- Strength, failure and damage analysis
- Thin ply composite shells & effects of material non-linearity
- Analysis and design of composite structures

Lecture notes
Script, handouts, exercises and additional material are available in PDF-format on the moodle page of the lecture.

Literature
The lecture material is covered by a script/lecture notes compiled by CMASLab and further literature is referenced therein.

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ECTS
101-0608-00L 4 credits

Lecture notes
As the course follows a lecture on demand approach, the lecture slides will be provided after each course.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

Prerequisites / notice
The students are expected to work out of class as well. The course time will be used by the teachers to answer project-specific questions. The lecture series will be conducted in English and is aimed at students of master's programs, particularly in civil engineering and MIBS. No lecture will be given during Seminar week.

3. Semester

Major Courses

Major in Construction and Maintenance Management

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<tr>
<td>101-0608-00L</td>
<td>Design-Integrated Life Cycle Assessment</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>G. Habert, A. Rodionova</td>
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Abstract
Currently, Life Cycle Assessment (LCA) is applied as an ex-post design evaluation of buildings, but rarely used to improve the building during the design process.

Objective
The course will follow two main objectives and a third optional objective, depending on the design projects the students’ choose. At the end of the course, the students will:
1. Know the methodology of LCA
2. Be able to apply LCA in the design process to assess and improve the environmental performance of their projects
3. Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation

Content
The course will be structured into two parts, each making up about half of the semester.

Part I: Exercises with lectures on demand
The first six individual courses will follow the “lectures on demand” approach. Small “hands-on” exercises focusing on one specific aspect will be given out and the necessary background knowledge will be provided in the form of short input lectures when questions arise. The following topics will be discussed during the first part:
1. LCA basic introduction
2. System boundaries, functional unit, end of life
3. Carbon budget and LCA benchmarks
4. BIM-LCA, available calculation tools and databases
5. Integrated analysis of environmental and cost assessment
6. Bio-based carbon storage

Part II: Project-based learning
In the second part, the students will work on their individual project in groups of three. For the design task, the students will bring their own project and work on improving it. The projects can be chosen depending on the students background and range from buildings to infrastructure projects. Intermediate presentations will ensure the continuous work and make sure all groups are on the same level and learn from each other. During this part, the following hands-on tutorials will be given:
1. Introduction to Rhinoceros 6 and 7
2. Introduction to grasshopper
3. Integrated assessment tools (ladybug tools)
4. Introduction to in-house grasshopper plugin for LCA analysis

Autumn Semester 2024
101-0577-00L  An Introduction to Sustainable Development in the Built Environment

Abstract
In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. This decarbonization strategy is additional to Sustainable Development goals formulated the same year by the UN general assembly. What does that mean for the built environment? This course provides an introduction to the notion of sustainable development when applied to our built environment.

Objective
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content
The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development and beyond

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification
- Method 4: Material Flow Analysis

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world

- Synthesis: Transition to sustainable development

Lecture notes
All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

101-0553-00L  Materials and Constructions

Abstract
Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Looking at material sourcing, properties and performance, as well as how they are integrated in the buildings (building envelope and detailing).
Choice of material is done out of sustainability concern.
Comfort, moisture transfer and building physics with hygroscopic materials.
Students will receive an introduction to circular principles by experts from the building industry and visit de- and construction sites where circular construction is exemplified. They will explore how to use digital technologies such as LiDAR scanning, photogrammetry, scanning to-BIM, computer vision, computational design, digital fabrication, blockchain technology and learn about the design implications using reclaimed building materials. This course is meant as an overview/introduction of many digital technologies that could be useful for circular construction and evaluate possible solutions using digital technologies to enable a circular built environment (more specifically, with reused building materials). To achieve this, they need to be able to do the following:

1. Apply circular principles using recovered building materials.
2. Compare different digital technologies applied in circular construction (e.g., LiDAR scanning, drone imagery, photogrammetry, computational design, AI, computer vision, XR, LCA tools etc.)
3. Understand the potential and limitations of AI for circular construction, e.g., use machine learning to detect and digitize materials (computer vision) or to support creativity in the early design phases of circular construction (generative AI).
4. Communicate the importance and urgency of circular construction.
5. Assess the environmental impact implications of their design and technology decisions through a preliminary Life Cycle Assessment (LCA).

The course will be taught at the Kunsthalle Zurich as part of an exhibition. By the end of this course, students will be able to use augmented computational design enabling circular construction, with a view to environmental implications. They will be able to assess the challenges and opportunities of low-carbon, circular construction and evaluate possible solutions using digital technologies to enable a circular built environment (more specifically, with reused building materials). To achieve this, they need to be able to do the following:

1. Apply circular principles using recovered building materials.
2. Compare different digital technologies applied in circular construction (e.g., LiDAR scanning, drone imagery, photogrammetry, computational design, AI, computer vision, XR, LCA tools etc.)
3. Understand the potential and limitations of AI for circular construction, e.g., use machine learning to detect and digitize materials (computer vision) or to support creativity in the early design phases of circular construction (generative AI).
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Language: English

Courses are on Tuesday afternoons in Kunsthalle or a room at ETH, but also require out-of-the-semester work and significant homework and site visits outside of class hours.
Link

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**Prerequisites / notice**

Interest in Digitalisation and Construction. Flexibility: This is a hands-on course, where students explore digital technologies and opportunities/challenges of reuse. Flexibility (e.g. adapting to unforeseen circumstances), responsibility (e.g. arriving on time for safety briefing), and spontaneity (e.g. finding innovative solutions) is expected from the students to adapt to the contingencies from demolition and construction sites with reused materials. The course is mandatory for MIBS students. If you are a first year MIBS student, please do not apply, you are automatically accepted. All other students from other departments should apply. Please only register for the course if you really intend to participate on all course dates (see course catalog). Please only register for the course if you are willing to send us a letter of motivation and really intend to participate; otherwise, you will deprive someone else of a place. All non-MIBS students who register go onto a waiting list until 11.09.2024 and up to 25 of them will be selected by the lecturer.

To register:
1. Enroll before 05.09.2024.
2. Send a short letter of motivation (max. 300 words) and a 1-page CV to cea-course@ibi.baug.ethz.ch by 05.09.2024.

Collaborators: Kunsthalle Zürich, ETH AI Center, Design++

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**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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**Major in Geotechnical Engineering**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
101-0329-00L | Tunnelling III | W | 4 credits | 2G | G. Anagnostou, E. Pimentel, M. Ramoni

**Abstract**

Deepen the knowledge on selected topics of underground construction as well as learning working out conceptual solutions of complex problems.

**Objective**

Lecture: Deepen the knowledge on selected topics of underground construction.
Exercises: Conceptual solutions of complex problems.

**Content**

Caverns: Geometry, construction methods, support.
Shafts: Construction methods, support.
Urban tunnelling: Boundary conditions, system choice, alignment, design.
Field measurements: Principles, monitoring layout, applications, interpretation.
Cut and cover tunnels: Modelling, design.
Exercising conceptual solution of complex tunnelling problems based upon discussion of current tunnel cases with particularly demanding problems in small groups.

**Lecture notes**

Autographieblätter

**Literature**

Empfehlungen

**Prerequisites / notice**

Prerequisite: BSc course "Tunnelling", MSc courses "Tunnelling I" and "Tunnelling II".

This course will continue to be offered in German up to and including HS24.

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**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Problem-solving

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**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
101-0339-00L | Environmental Geotechnics – Polluted Sites and Waste Disposal | W | 3 credits | 2G | M. Plötze

**Abstract**

The practice of landfiling, remediation of polluted sites and the disposal of radioactive waste are based on the same concepts of environmental protection. Understanding the contaminants behaviour and how to reduce their release to the environment is the key to remediating polluted sites and designing multi-barrier systems.

**Objective**

On successful completion of this course students will be able to
- Assess the risk to the environment from landfills, contaminated sites and radioactive waste repositories in terms of the fate and transport of contaminants.
- Describe the technologies available to minimise environmental contamination
- Describe the principles of dealing with polluted sites and propose and evaluate appropriate remediation techniques
- Explain the concepts underlying radioactive waste management practices.
This lecture course consists of lectures with exercises and case studies.
- An overview of the principles of environmental protection in waste management and how this is applied in legislation.
- An overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes controlling mobility of heavy metals and organic compounds
- Introduction to contaminant transport in porous adsorbing media
- Design and function of engineered barriers. Clay as a barrier.
- Polluted site remediation: Site investigation, assessment, and remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

Prerequisites / notice

Competencies

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101-0367-00L Geotechnical Engineering in Transportation and Pavement Design

Objective

Students should be able to recognise basic structural and material-related connections in traffic route engineering as well as be able to design pavements. This includes knowledge of the interrelation of local conditions such as soil properties, climate, water, as well as the mechanical behaviour of the selected construction materials and the quality of the design models involved.

Content

The content of the lecture is divided into the parts "geotechnical fundamentals in transportation", "construction technology and materials" and "pavement design". In the first part, soil stabilization, artificial compaction, testing of soils as well as the effects of frost are discussed for traffic route engineering. Thereafter, knowledge of the building materials and construction methods used in transportation is imparted with reference to European and national standards. After conveying some introductory concepts on the structural behaviour of asphalt, different design methods and models for pavements are subsequently examined.

This knowledge is conveyed through lectures, practical demonstrations, moderated exercises and assignments (to be completed independently).

Lecture notes

Slides, exercise and homework sheets, handouts

Literature

According to the bibliography in the submitted documents

Prerequisites / notice

Basic knowledge in "soil mechanics".

101-0119-00L Structural Masonry

Objective

Knowledge of the engineering properties of materials for masonry construction.

Technical understanding of the structural behaviour of load-bearing masonry structures subjected to in-plane forces and combined actions.

Develop a technical competence for design procedures for load-bearing masonry structures by means of exercises.
### 101-0129-00L Non Destructive Evaluation & Rehabilitation of Existing Structures

**Abstract**
Introduction to non destructive evaluation tools and quantitative structural analyses and verifications for condition assessment of existing structures and subsequent decisions on their rehabilitation.

**Objective**
The goal is for students to familiarize themselves with the handling of assessment and rehabilitation of existing structures from the perspective of a consulting engineer, following a systematic approach as described in current codes and to further learn how to use new non-destructive evaluation technologies.

**Content**
This course is organized in two main pillars. The first pillar describes the technologies that are available for non destructive evaluation of existing structures and delves into description of the principle of operation of such methods (e.g. wave propagation, acoustic emission analysis, tomography). The second pillar, overviews the current implementation of condition assessment processes in codes and standards. Complementary to the topic of structural evaluation, the topic of interventions, rehabilitation and retrofitting of existing structures for different construction materials is next addressed.

**Prerequisites / notice**
Advanced Structural Concrete

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<td>Media and Digital Technologies</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Problem-solving</td>
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<td>Self-presentation and Social Influence</td>
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<td>Project Management</td>
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<td>Sensitivity to Diversity</td>
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<td>assessed</td>
<td>Negotiation</td>
<td>fostered</td>
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</table>

**Literature**
- "Mauerwerk, Bemessungsbeispiele zur Norm SIA 266", SIA Dokumentation D0257, 2015
- "Mauerwerk", Norm SIA 266, 2015
- "Mauerwerk - Ergänzende Festlegungen", Norm SIA 266/1, 2015
- Swiss Standards SIA 269, 269/1 to 269/7
- SIA-Document D 0239 «Existing Structures – Introduction» (in German/French)
- SIA-Document D 0239 «Existing Structures – Consolidation and Practice» (in German/French)

**Lecture notes**
Lecture notes

**101-0159-00L Method of Finite Elements II**

**Abstract**
The Method of Finite Elements II is a continuation of Method of Finite Elements I. Here, we explore the theoretical and numerical implementation concepts for the finite element analysis beyond the linear elastic behavior. This course aims to offer students with the skills to perform nonlinear FEM simulations using coding in Python.

*This course offers no introduction to commercial software.*

**Objective**
This class overviews advanced topics of the Method of Finite Elements, beyond linear elasticity. Such phenomena are particularly linked to excessive loading effects and energy dissipation mechanisms. Their understanding is necessary for reliably computing structural capacity. In this course, instead of blindly using generic structural analysis software, we offer an explicit understanding of what goes on behind the curtains, by explaining the algorithms that are used in such software.

The course specifically covers the treatment of the following phenomena:
- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

Upon completion of the course, the participants will be able to:
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems.

**Literature**
- SIA-Document D 0239 «Existing Structures – Introduction» (in German/French)
- SIA-Document D 0239 «Existing Structures – Consolidation and Practice» (in German/French)

**Lecture notes**
The course slides serve as Script. These are openly available on: http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html

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Analytical Competencies

Subject-specific Competencies

Design of Reinforced Concrete Buildings for Seismic Performance: Practical Deterministic and Probabilistic Approaches (1st ed.).

After successfully completing this course, the students will be able to:

Seismic Design of Structures II

B. Stojadinovic

In this course the students will learn how to do performance-based seismic design of building structures. This is a project-based course.

Moodle is used to manage the course learning material. These include the lecture presentations, additional reading, exercise problems and solutions, example models of structures in OpenSees system for earthquake engineering simulation, and example designs.

This course completes the series of courses on dynamic analysis and seismic design of structures at ETHZ. Building on the material covered in Structural Dynamics and Seismic Design of Structures I (101-0188-00 G) and in the primary target group (majoring in Structural Engineering and/or doing project-based coursework for other majors).

101-0189-00L

Seismic Design of Structures II

W 4 credits 2G B. Stojadinovic

Number of participants limited to 18.

All students go on a waiting list. Final registration based on an application letter (information given in the first lecture). Priority will be given to students who completed Seismic Design of Structures I (101-0188-00 G) and are in the primary target group (majoring in Structural Engineering and/or doing project-based coursework for other majors).

Abstract

In this course the students will learn how to do performance-based seismic design of building structures. This is a project-based course. The students will, in parallel, acquire the basis knowledge about the seismic behavior and non-linear response modeling of structures, and apply this knowledge in a project focused on design of a new building.

Objective

After successfully completing this course, the students will be able to:

1. Model and explain the seismic behavior of new structures with moment frame, braced frame and shear wall structural systems.
2. Evaluate the performance of new structures under earthquake loading using modern risk-informed performance assessment methods and analysis tools.
3. Use the knowledge of nonlinear dynamic response of structures to interpret the design code provisions and apply it in seismic design of structural systems.
4. Successfully design such systems to achieve the performance objectives stipulated by the design codes.

Content

This course completes the series of courses on dynamic analysis and seismic design of structures at ETHZ. Building on the material covered in Structural Dynamics and Seismic Design of Structures I, the following advanced topics will be covered in this course: 1) behavior and non-linear response modeling of structural systems under earthquake excitation; 2) displacement-based inelastic design of new building structures; 3) seismic design of moment frame, braced frame and shear wall structures. These topics will be discussed from the standpoint of risk-informed performance-based seismic design.

Lecture notes

Moodle is used to manage the course learning material. These include the lecture presentations, additional reading, exercise problems and solutions, example models of structures in OpenSees system for earthquake engineering simulation, and example designs.

Literature

Design of Reinforced Concrete Buildings for Seismic Performance: Practical Deterministic and Probabilistic Approaches (1st ed.).


Earthquake Engineering: From Engineering Seismology to Performance-Based Engineering, Borzorgnia, Y. and Bertero, V. Eds., CRC Press, 2004


Prerequisites / notice

ETH Seismic Design of Structures I course, or equivalent. Students are expected to understand the seismological nature of earthquakes, to characterize the ground motion excitation, to analyze the response of elastic single- and multiple-degree-of-freedom systems to earthquake excitation, to use the concept of response and design spectrum, to compute the equivalent seismic loads on simple structures, and to perform code-based seismic design of simple structures. Familiarity with structural analysis software, such as SAP2000 or OpenSees, and general-purpose software, such as Python and Matlab, is expected.

Number of participants limited to 10. All students go on a waiting list. Final registration based on an application letter (information given in the first lecture). Priority will be given to students who completed Seismic Design of Structures I (101-0188-00 G) and are in the primary target group (majoring in Structural Engineering and/or doing project-based coursework for other majors).
This course will cover the analysis and design of isolation systems to mitigate earthquakes and other forms of vibrations. The course will cover:

1. Conceptual basis of seismic isolation, seismic isolation types, mechanical characteristics of isolators.
3. Design approaches and code requirements.

After successfully completing this course the students will be able to:

1. Understand the mechanics of and design isolator bearings.
2. Understand the dynamics of and design an isolated structure.

There is no single textbook for this course. However, most of the lectures are based on parts of the following books:

- Dynamics of Structures, Theory and Applications to Earthquake Engineering, 4th edition, Anil Chopra, Prentice Hall, 2017
- Design of seismic isolated structures: from theory to practice, Farzad Naeim and James M. Kelly, John Wiley & Sons, 1999
- Mechanics of rubber bearings for seismic and vibration isolation, James M. Kelly and Dimitrios Konstantinidis, John Wiley & Sons, 2011

The electronic copies of the learning material will be uploaded to ILIAS and available through myStudies. The learning material includes: reading material, and (optional) exercise problems and solutions.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
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<td>Objective</td>
<td>After successfully completing this course the students will be able to:</td>
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<tr>
<td>Content</td>
<td>1. Introduction: Overview of seismic isolation; review of structural dynamics and earthquake engineering principles. Viscoelastic behavior.</td>
<td>2. Linear theory of seismic isolation</td>
<td>1. Adaptability and Flexibility</td>
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<td>Lecture notes</td>
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<td>The goal of the course is to introduce students to Structural Design. The course fosters the development of a design thinking that emerges from the coexistence of a number of design parameters and performance criteria related to force flow, construction technologies, material use, and spatial qualities.</td>
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<tr>
<td>Abstract</td>
<td>The goal of the course is to introduce students to Structural Design. The course fosters the development of a design thinking that emerges from the coexistence of a number of design parameters and performance criteria related to force flow, construction technologies, material use, and spatial qualities. Students will learn about diverse tools that allow for controlling such a complex blend of parameters and criteria at the interface between different disciplines such as structural engineering and architecture. These tools will include physical models, graphical methods, and digital tools. After a series of lectures and workshops, students will work on a design exercise that represents the core of the entire course. The design exercise is an opportunity to deal with an open-ended task that does not admit a univocal answer. In fact, besides structural performance, design options will be discussed and evaluated through a set of criteria including spatial qualities, constructability, and environmental footprint.</td>
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</table>
Prerequisite: Timber Structures I (101-0168-00L).

Students who have not completed Holzbau I require a special permission from the lecturer.

B. Bickel

R. Jockwer, M. Muster, S. Schilling, R. Steiger

Prerequisite / notice

101-0120-00L Structural Glass Design and Facade Engineering W 3 credits 3G V.-A. Silvestru

Abstract

The course gives an introduction to structural glass design and related façade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.

Objective

After successful completion of the course, students will be able to:
- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;
- Recognize requirements for glass elements depending on their application area and chose the appropriate glass products and assemblies accordingly;
- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;
- Apply selected approaches for the structural design of in-plane loaded glass elements;
- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.

Content

This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

Lectures:
The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent façades.

Design exercises:
The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Design project:
The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

Lecture notes

The lectures are based on lecture slides and handouts.

Literature

Recommended and supplementary literature:

Prerequisites / notice

Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed

Personal Competencies
- Creative Thinking fostered
- Critical Thinking fostered

101-0139-00L Scientific Machine and Deep Learning for Design and Construction W 3 credits 4G B. Bickel, A. Müller, M. Piovacci
Abstract
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

Objective
This course aims to provide a graduate-level introduction to machine learning, with a particular focus on scientific machine learning for applications in the design and construction phases of projects from architecture and civil engineering.

Upon completion of the course, the students will be able to:
1. Understand main ML background theory and methods.
2. Assess a problem and apply ML and DL in a computational framework accordingly.
3. Incorporate scientific domain knowledge in the SciML process.
4. Define, plan, conduct and present a SciML project.

Content
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
2. Incorporation of Domain Knowledge into ML and DL.
4. ML training, validation and testing pipelines for academic and research projects.

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

Lecture notes
The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Literature
Suggested Reading:
Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
O. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016
O. Martin: Bayesian analysis with python. Packt Publishing Ltd, 2016

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management assessed
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Creative Thinking fostered
Critical Thinking fostered
Self-direction and Self-management fostered

Prerequisites / notice
Familiarity with Python is advised.

101-0138-11L Bridge Design: Project Competition W 4 credits 2S W. Kaufmann

Abstract
This module offers the possibility to apply the fundamentals of the course Bridge Design in a conceptual design project. The scenario is set as a design competition: The students (group of two) will get a basic documentation (service criteria agreement, plans, digital terrain model, geotechnical report, photo documentation, etc.) and will develop a conceptual design suitable for the given site.

Objective
At the end of the course, students will have developed a convincing bridge design that satisfies following criteria:
_ Consideration of governing boundary conditions and constraints.
_ Conception of an efficient structural system with an adequate aesthetic expression considering the environment.
_ Definition of the relevant actions and decisive load cases.
_ Proof of feasibility by dimensioning the main structural elements.
_ Schematic overview of construction processes.
_ Appropriate presentation and visualisation of the proposed bridge design.

Content
The module is built up as follows:
0. Presentation of problem statement / project. (1st week of semester)
1. Introduction to design tools & working methods.
   a. Define requirements and boundary conditions.
   b. Study of references and possible concepts
   c. Choice of best variant
   d. Structural modelling & calculations
   e. Plans & visualisation
2. Working on project (milestones):
3. Presentation of your work in a mid-term and a final critique.
4. Submission

Prerequisites / notice
101-0138-00L Bridge Design or an equivalent attestation of knowledge in bridge design.
### Major in Transport Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0469-00L</td>
<td>Road Safety</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>M. Deublein, P. Eberling</td>
</tr>
<tr>
<td>Abstract</td>
<td>The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety Aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.</td>
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<td>Objective</td>
<td>Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety</td>
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<tr>
<td>Content</td>
<td>Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy</td>
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<td>Further literature: will be presented during the course</td>
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<td>101-0491-00L</td>
<td>Agent Based Modeling in Transportation</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>M. Balac, G. O. Kagho</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based simulation models’ current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in groups.</td>
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<td>Objective</td>
<td>At the end of the course, the students should:</td>
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<tr>
<td>Content</td>
<td>- have an understanding of agent-based modeling</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Additional relevant readings, primarily scientific articles, will be recommended throughout the course.</td>
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<td>Competencies</td>
<td>Subject-specific Competencies Technological Competencies Analytical Competencies Problem-solving Project Management Assessed Assessed Fostered Fostered Fostered</td>
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<td>Social Competencies</td>
<td>Cooperation and Teamwork Fostered</td>
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<td>Personal Competencies</td>
<td>Critical Thinking Assessed</td>
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<td>101-0492-00L</td>
<td>Microscopic Modelling and Simulation of Traffic Operations</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Makridis</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.</td>
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<tr>
<td>Objective</td>
<td>The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication. Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario. Upon completion of the course, the students will have: - Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.). - Design a road transport network inside the simulation software. - Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network. - Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure. - Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.</td>
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Content

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:
1) Car following models
2) Lane change models
3) Calibration and validation methodology
Specific tasks for the project will include:
1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/extend the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Objective

The lecture gives a deeper insight into railway technology, the interaction between track and vehicles as well as in construction and dimensioning of the track. Methods for starting up and the diagnosis of the state of the track and its forecast are shown. State-of-the-art maintenance strategies and technologies are presented.

Abstract

Railway technology; interaction between track and vehicles; stress; track construction including features of railway bridges and tunnels; starting up; track diagnostics and forecast; track maintenance and related methods.

Objective

The lecture gives a deeper insight into railway technology, the interaction between track and vehicles as well as in construction and dimensioning of the track. Methods for starting up and the diagnosis of the state of the track and its forecast are shown. State-of-the-art maintenance strategies and technologies are presented.
Content
1 - Railway technology
Track, power supply / catenaries, information technology, safety / interlockings / dispatching

2 - Interaction
Interaction between track and vehicles, vehicle dynamics

3 - Railway Track
Stress; track construction including special features of railway bridges and tunnels

4 - Starting up
Goals, methods, procedures

5 - Diagnostics, maintenance strategies
Track diagnostics and forecast

6 - Track maintenance
Maintenance strategies, fundamentals of track maintenance and related methods

Lecture notes
The slides will be made available.

Literature
A list with related technical literature will be handed out.

Prerequisites / notice
Prerequisite: 101-0419-01 Railway Infrastructures 1 (FS)

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Social Competencies
Customer Orientation
Sensitivity to Diversity

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics

101-0491-10L Basics of Java and Best Practices for Scientific Computing
W 1 credit 1U M. Balac

Abstract
This course provides an introduction to programming in Java, version control, and cloud computing.

Objective
At the end of the course, the students should
● Have acquired object-oriented programming skills with a focus on Java.
● Have an understanding of version control using git
● Have learned to deploy java applications on servers

Content
This course provides an introduction to object-oriented programming with Java. Four topics are covered:
● Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods,...)
● Injection (traditional vs. Guice)
● Code versioning
● Java application deployment on servers

Literature
Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang
Abstract
The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

Objective
The objectives of the courses are to:
- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

Content
The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Lecture notes
Digital lecture handouts will be distributed prior to each class.

Literature
Links to relevant literature will be provided during the classes.

Prerequisites / notice
Completed BSc studies. Basic knowledge in computer scripting in any language (e.g., Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork assessed
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management assessed

101-1249-00L Hydraulics of Engineering Structures W 3 credits 2G I. Albayrak, F. Evers
Abstract
Hydraulic fundamentals are applied to hydraulic structures for wastewater, flood protection and hydropower. Typical case studies from engineering practice are further described.

Objective
Understanding and quantification of fundamental hydraulic processes with particular focus on hydraulic structures for wastewater, flood protection and hydropower.

In the course "Hydraulics of Engineering Structures", the competencies of process understanding, system understanding and measurement methods are taught, applied and examined. The competencies modeling, concept development and data analysis & interpretation are taught and data analysis & interpretation is applied in addition.

Content
1. Introduction & Basic equations
2. Losses in flow & Maximum discharge
3. Uniform flow & Critical flow
4. Hydraulic jump & Stillling basin
5. Backwater curves
6. Weirs & End overfall
7. Sidewer & Side channel
8. Bottom opening, Venturi & Culverts, Restrictors, Inverted siphons
9. Fall manholes & Vortex drop
10. Supercritical flow & Special manholes
11. Aerated flows & Low level outlets
12. Hydraulics of sediment bypass tunnels
13. Vegetated flows - Introduction & Application
14. Summary

Lecture notes
Text books


Literature
Exhaustive references are contained in the suggested text book.

102-0215-00L Urban Water Management II W 4 credits 2G P. Staufer
Abstract

Objective
Vertiefung der Grundlagen für die Dimensionierung anspruchsvoller Bauwerke mithilfe der numerischen Simulation und Darstellung der Ergebnisse für Zielgruppen in der schweizerischen Wasserwirtschaft.

Content
Generelle Entwässerungsplanung (GEP)
- Siedlungshydrologie: Niederschlag, Ablussbildung
- Stofftransport in der Kanalisierung
- Emissions- und Immissionsbetrachtungen, Einleitbedingungen
- Versickerung von Regenwasser
- Blau-grüne Infrastrukturen (BGI)

Lecture notes
Die schriftlichen Unterlagen stehen digital zur Verfügung.

Prerequisites / notice
Als Voraussetzung wird der Besuch der Lernveranstaltung "Siedlungswasserwirtschaft GZ" empfohlen.
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

Techniques and Technologies: assessed

Decision-making: assessed

Media and Digital Technologies: fostered

Problem-solving: assessed

Project Management: fostered

101-1250-00L Transport Processes in Torrents W 3 credits 2V I. Schalko

Abstract
This course focuses on the various transport processes in torrents. This includes discharge, bedload, debris flow, and large wood. Differences between transport processes in rivers versus torrents will be discussed. Special focus will be put on the (1) analysis of the interaction between the transport processes (cascading processes) and the (2) design of countermeasures.

Objective
At the end of the course, the students will be able to:
(1) Describe the different transport processes in torrents, such as flow discharge or bedload transport,
(2) discuss how cascading processes affect the resulting natural hazard, and
(3) derive solutions for a sustainable hazard management.

Content
The first part of the lecture introduces the different transport processes in torrents such as discharge, bedload, debris flow, and large wood. This will include methods to determine and calculate the discharge, characterize debris flow, and quantify wood load.

In the second part of the lecture, special focus will be put on the cascading effects (what happens if multiple transport processes occur at once) and their implications on the resulting natural hazards.

The last part of the lecture focuses on the design of countermeasures such as check dams and will include examples from selected catchments in Switzerland.

Two field trips are planned to illustrate the transport processes and existing countermeasures.

Literature

Prerequisites / notice
Recommended lectures:
- Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), Hydraulic Engineering (101-0206-00L), River Engineering (101-0258-00L)

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: assessed

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-direction and Self-management: fostered

Major in Materials and Mechanics

Number Title Type ECTS Hours Lecturers
101-0639-01L Science and Engineering of Glass and Natural Stone in Construction W 3 credits 2G

Does not take place this semester.

Abstract
The course offers an overview of relevant practical issues and present technological challenges for glass and natural stones in constructions. Students gain a good knowledge of the basics of glasses and natural stones, their potential as engineering materials and learn to apply them in the design of civil engineering constructions and to evaluate concepts.
Objective

Glass is increasingly used in constructions to ease the construction process, as functional insulation barrier, even for structural applications of impressive size. While everyone has experienced the innovation potential of glass in the last decade, products from natural stone suffer from an unjustified traditional image that often originates from a lack of understanding of the material and its combination with other materials. Culturally important structures often are made from natural stone and their conservation demands an understanding of their deterioration mechanisms, the concepts of which can be applied to other civil engineering materials. Designers and engineers need the knowledge to reconcile materials and system behavior with the entire processing, handling, integration and life time in mind.

In this module students are provided with a broad fundamental as well as practice-oriented education on glass and natural stone in civil engineering applications. Present and future construction and building concepts demand for such materials with optimized properties. Based on the fundamentals from the Bachelor course in materials by the end of this module, you should be able to:

- recognize and choose specific applications from the broad overview you were provided with,
- relate processing technologies to typical products and building applications and recognize (and explain typical damage related to wrong material choice or application,
- explain the nature of glassy and crystalline materials and interpret their physical behavior against this background,
- explain the major deterioration mechanisms in natural stone and how this relates to durability,
- analyze material combinations and appraise their application in future products as well as integration in existing constructions,
- summarize with appropriate guidance publications on a related topic in an oral presentation and short report.

Content

Lecture 1: An introduction to science and engineering of glass and natural stone in construction (FW/TW)

Lecture 2: Glass chemistry including historical development of glass composition, use of raw materials, melts, chemical stability and corrosion. (FW)

Lecture 3: Geology and mineralogy of stones used in construction. Formation processes, chemistry, crystal structure. (TW)

Lecture 4: Microscopic models for glassy materials. Physics of vitrification. From microscopic physical models to thermodynamics, rheology and mechanics of glassy materials. (FW)

Lecture 5: Stone properties and behavior: microstructure, density, porosity, mechanical properties (TW)

Lecture 6: Glass physics: Optical properties (transmission, reflection, emission, refraction, polarization and birefringence, testing methods); Mechanical properties (density, thermal, mechanical, electric properties, glass testing) (FW)

Lecture 7: Stone properties and durability: transport, moisture and thermal cycling (TW)

Lecture 8: Forming and processing of glass: (plate and molded glass, drawing, slumping, profiling etc.; Processing: Cutting, mechanical processing, tempering, gluing, bending, laminating of glass Surface treatments: coating, sputtering, enameling, printing, etching, chemical pre-stressing.) (FW)

Lecture 9: Durability: Salt crystallization, freezing, biodeterioration (TW)

Lecture 10: Glass products for civil engineering applications: (Molded glasses, fiber glass, foam glass, plate glass); construction glass (insulation glass, structural glass, protective glass, intelligent glass, codes); (FW)

Lecture 11: Conservation: Consolidation, cleaning, and other treatments (TW).

Lecture 12: Glass in constructions. (modeling, application and regulation, typical damage in glass) (FW)

Lecture 13: Student presentations; exam questions (FW/TW)

Lab 1: Durability of natural stone (FW/TW)

Lab 2: Fracture of glass (FW/TW)

Will be handed out in the lectures

Literature

Werkstoffe II script (download via the IFB homepage). Rest will be handed out in the lectures

Prerequisites / notice

Werkstoffe II/III of the bachelor studies or equivalent introductory materials lecture.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Self-direction and Self-management</td>
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</tbody>
</table>

101-0659-01L Durability and Maintenance of Reinforced Concrete

W 4 credits 2V U. Angst, Z. Zhang

Abstract

We look at the durability of reinforced concrete structures, covering common deterioration processes such as reinforcement corrosion, frost damage, ASR, etc. The course spans the range from fundamental mechanisms to aspects of engineering practice. New methods and materials for preventative measures, condition assessment and repair techniques are treated. Examples from real cases are shown.
The course is based on the book Analytical Competencies, M. Wyrzykowski.

3 credits

Subject-specific Competencies
- Degradation mechanisms for concrete: sulphate attack, ASR, frost attack.
- Inspection and condition assessment: Chloride analyses, carbonation depth, etc. Non-destructive tests, particularly potential mapping to detect corrosion. New developments (for example, monitoring with sensors).

Method-specific Competencies
- Stainless steel as reinforcing steel for concrete: Different types of stainless steels. Coupling with black reinforcing steel. Examples of application. Life-cycle-costs.
- Modern materials and construction technologies: Discussion of expected implications for the durability of structures today and in the future.

Content

Excursion:
- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Lecture notes


Prerequisites / notice

We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Literature


Form of teaching:
The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

Report:
Each student will work on a small case study and deliver a report during the semester. The report will be graded.

Excursion:
We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract

Concrete is generally viewed as a durable construction material. However, the long-term performance of a concrete structure can be greatly compromised by early-age cracking. This course will explain how shrinkage of concrete leads to cracking and how control of shrinkage allows increasing the expected durability of a concrete structure.
This course will begin with a brief introduction about hydration and microstructure development in cement paste and concrete. The students will learn the main causes of cracking at early ages, namely plastic, drying, thermal and autogenous shrinkage, with special emphasis on the driving mechanisms. The importance of concrete curing, especially in the first few days after casting, will be stressed and explained. Building on the knowledge of the driving forces of shrinkage, the way of action of shrinkage-reducing admixtures will be clarified and different applications illustrated. As an extension of external curing, the students will become familiar with internal water curing by means of saturated lightweight aggregates and superabsorbent polymers. Most concrete members are restrained by adjacent structures. When shrinkage is restrained, cracks may develop. The students will learn how to apply different criteria for assessing concrete cracking and how to retrieve the mechanical properties of the concrete, especially stiffness and creep, which are needed for the calculations of self-induced stresses and risk of cracking.

In addition to macroscopic cracks, microcracking may occur in the cement paste due to inner restraint offered by the aggregates. Both macroscopic cracks and diffuse microcracking within a concrete may facilitate the ingress of harmful substances (e.g. chloride and sulfate ions) into the concrete; these may react with the concrete or with the reinforcement and create further deterioration. The students will acquire an understanding of the mechanisms of transport through cracked concrete, with special focus on experimental evidence and on techniques able to visualize the transport process and follow it in time. As a final outcome of the course, the students will be able to estimate the impact of cracking on the expected durability of concrete structures and to implement different types of measures to reduce the extent of cracking.

Advances in concrete technology over the past decades have led to the practical use of concrete with a low water to binder ratio and with different types of mineral and organic admixtures. Another recent development is self-compacting concrete, which avoids concrete vibration and reduces labor during placing. Unfortunately, these concretes are especially prone to cracking at early ages, unless special precautions are taken. Proper curing becomes in this case the key to achieve better performance in various environmental and load conditions. Specific topics covered by the course:

- Hydration and microstructure development
- Plastic shrinkage
- Development of mechanical properties
- Thermal deformation
- Autogenous deformation
- Drying shrinkage
- Creep and relaxation
- Curing
- Shrinkage-reducing admixtures
- Internal curing: saturated lightweight aggregates and superabsorbent polymers
- Fracture and microcracking
- Transport in cracked concrete
- Impact of cracking on concrete durability
- Self-healing of cracks

For each lecture, lecture notes will be provided. In addition, one or two research papers for each lecture will be indicated as supportive information.

Copies of one to two research papers relevant to the topic of each lecture will be provided to the students as supportive information.

A basic knowledge of concrete technology is preferable.

The course Wood structure and function conveys basic knowledge on the microstructure of softwoods and hardwoods as well as general aspects of sustainability in wood production. In terms of bulk wood products, a specific focus is laid on sawn timber production and drying processes. Concerning wood veneer production, steaming, veneer cutting, and assembly to veneer lumber products are presented.

Further, the common technologies for the production of particle boards and fibre boards will be discussed. Topics related to wood gluing and wood protection as well as potentials and limitations in the application of wood and wood-based products are covered. In a further part, the lecture deals with the most important digital technologies, e.g. Internet of Things, artificial intelligence, and their impact on the wood industry based on illustrative examples.

101-0637-10L

**Objective**

Learning target is a basic understanding of the anatomy of wood and the related impact of endogenous and exogenous factors. The students can learn how to distinguish common central European wood species at the macroscopic and microscopic level. A deeper insight will be given by wood identification exercises for softwood species. Further, the students will gain insight into the relationships between tree growth and wood properties with a specific focus on the wood function in the living tree.

**Content**

In an introduction to wood anatomy, the general structural features of softwoods and hardwoods will be explained and factors of diversity and variability will be discussed. A specific focus is laid on common central European tree species with relevance in the wood sector, which will be studied in macro- and microstructural investigations. In the following, relationships between wood structure, properties and function in the living tree will be in the focus of the lectures. Topics covered are water transport, trends in wood anatomy within trees, environmental impact on wood anatomy, wood defects and their causes, tools to study wood properties over time, secondary changes in wood, and tree biomechanics.

**Competencies**

- Subject-specific Competencies
- Method-specific Competencies

**101-0637-20L**

**Objective**

The learning target is a fundamental understanding of the dominating wood processing chains, which are applied to fabricate common wood products. Students will be introduced to the economic relevance of the renewable resource wood and are trained in its technological properties. The students will learn to identify the relationships between wood species and their properties as well as the suitable wood machining processes to fabricate targeted wood products. Finally, the digital transformation process, which will affect all sectors of the wood industry with an impact on the entire value chain and business models will be covered. It will be illustrated how production processes can become more flexible, efficient and less resource-demanding.

**Content**

The general introduction shows the economic relevance of the resource wood in a global, European, and Swiss context and reflects aspects of sustainability in wood production. In terms of bulk wood products, a specific focus is laid on sawn timber production and drying processes. Concerning wood veneer production, steaming, veneer cutting, and assembly to veneer lumber products are presented. Further, the common technologies for the production of particle boards and fibre boards will be discussed. Topics related to wood gluing and wood protection as well as potentials and limitations in the application of wood and wood-based products are covered. In a further part, the lecture deals with the most important digital technologies, e.g. Internet of Things, artificial intelligence, and their impact on the wood industry based on illustrative examples.

**Competencies**

- Techniques and Technologies assessed
- Media and Digital Technologies assessed

**101-0159-00L**

**Objective**

The Method of Finite Elements II is a continuation of Method of Finite Elements I. Here, we explore the theoretical and numerical implementation concepts for the finite element analysis beyond the linear elastic behavior. This course aims to offer students with the skills to perform nonlinear FEM simulations using coding in Python. *This course offers no introduction to commercial software.*
This class overviews advanced topics of the Method of Finite Elements, beyond linear elasticity. Such phenomena are particularly linked to excessive loading effects and energy dissipation mechanisms. Their understanding is necessary for reliably computing structural capacity. In this course, instead of blindly using generic structural analysis software, we offer an explicit understanding of what goes on behind the curtains, by explaining the algorithms that are used in such software.

The course specifically covers the treatment of the following phenomena:
- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

Upon completion of the course, the participants will be able to:
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems.

See the class webpage for more information:

Course Slides (Script): http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html

Useful (optional) Reading:

Prerequisites:
- 101-0158-01 Method of Finite Elements I (FS)
- A good knowledge of Python is necessary for attending this course.

Self-awareness and Self-reflection
Integrity and Work Ethics
Critical Thinking
Creative Thinking
Problem-solving
Adaptability and Flexibility
Cooperation and Teamwork
Analytical Competencies
Concepts and Theories

Projects

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<td>Project on Construction Engineering</td>
<td>W</td>
<td>11</td>
<td>24A</td>
<td>Supervisors</td>
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<td>Objective</td>
<td>Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.</td>
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<td>Content</td>
<td>The project work is supervised by a professor. Students can choose from different subjects and tasks.</td>
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<td>101-0698-10L</td>
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### 101-0317-00L  
**Tunnelling I**  

<table>
<thead>
<tr>
<th>Credit</th>
<th>Lecture notes</th>
<th>Literature</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>W 3 credits G 2G</td>
<td>- Autographieblätter</td>
<td>- Empfehlungen</td>
<td>- This course will continue to be offered in German up to and including HS24.</td>
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</tbody>
</table>

#### Abstract
Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.

#### Objective
Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.

#### Content
Numerical analysis methods in tunnelling. Conventional excavation methods (full face, top heading and bench, side drift method, ...). Auxiliary measures: - Injections - Jet grouting - Ground freezing - Drainage - Forepoling - Face reinforcement

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### 101-0187-00L  
**Structural Reliability and Risk Analysis**  

<table>
<thead>
<tr>
<th>Credit</th>
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</tr>
</thead>
<tbody>
<tr>
<td>W 3 credits G 2G</td>
<td>- Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.</td>
<td>- Basic course on probability theory and statistics</td>
<td>- Special permission from the instructor can be requested if the student has not taken Verkehr III.</td>
</tr>
</tbody>
</table>

#### Abstract
Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.

#### Objective
The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

#### Content
Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro- codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

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### 101-0437-00L  
**Traffic Engineering**  

<table>
<thead>
<tr>
<th>Credit</th>
<th>Lecture notes</th>
<th>Literature</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>W 6 credits G 4G</td>
<td>- Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.</td>
<td>- Ang, A. and Tang, W.H. Probability Concepts in Engineering - Emphasis on Applications to Civil and Environmental Engineering, 2nd Edition, John Wiley &amp; Sons, 2007.</td>
<td>- Special permission from the instructor can be requested if the student has not taken Verkehr III.</td>
</tr>
</tbody>
</table>

#### Abstract
Fundamentals of traffic flow theory and control.

#### Objective
The objective of this course is to fully understand the fundamentals of traffic flow theory in order to effectively manage traffic operations. By the end of this course students should be able to apply basic techniques to model different aspects of urban and inter-urban traffic performance, including congestion.

#### Content
Introduction to fundamentals of traffic flow theory and control. Includes understanding of traffic data collection and processing techniques, as well as data analysis, traffic modeling, and methodologies for traffic control.

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### 101-0417-00L  
**Transport Planning Methods**  

<table>
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<tr>
<th>Credit</th>
<th>Lecture notes</th>
<th>Literature</th>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>W 6 credits G 4G</td>
<td>- Verkehr III - Road Transport Systems 6th Sem. BSc (101-0415-00L)</td>
<td>- Special permission from the instructor can be requested if the student has not taken Verkehr III.</td>
<td>- Verkehr III - Road Transport Systems 6th Sem. BSc (101-0415-00L)</td>
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</tbody>
</table>

#### Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

#### Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool
Agent Based Modeling in Transportation

This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based simulation models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in groups.

At the end of the course, the students should:
- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform transportation studies

This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained.
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.


MATSim

Agent-based modeling in general


Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

For those without object-oriented programming experience, a crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

Competency

Subject-specific Competencies

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Project Management

Social Competencies

Cooperation and Teamwork

Personal Competencies

Critical Thinking

Numerical Hydraulics

The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.

The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

Slides from the lectures and programs used can be downloaded.
The Method of Finite Elements II is a continuation of Method of Finite Elements I. Here, we explore the theoretical and numerical implementation concepts for the finite element analysis beyond the linear elastic behavior. This course aims to offer students with the skills to perform nonlinear FEM simulations using coding in Python. This course offers no introduction to commercial software.

Upon completion of the course, the participants will be able to:
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems.

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

The course specifically covers the treatment of the following phenomena:
- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The course slides serve as Script. These are openly available on: [http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html](http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html)

Useful (optional) Reading:

Prerequisites:
- 101-0158-01 Method of Finite Elements I (FS)
- A good knowledge of Python is necessary for attending this course.

Prerequisites / notice

Lecture notes


Literature


Useful (optional) Reading:

Prerequisites:
- 101-0158-01 Method of Finite Elements I (FS)
- A good knowledge of Python is necessary for attending this course.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies

- Communication
- Cooperation and Teamwork

Personal Competencies

- Critical Thinking
- Integrity and Work Ethics

101-0159-00L Method of Finite Elements II

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<tr>
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<td>Method-specific Competencies</td>
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<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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101-0617-02L Computational Science Investigation for Material Mechanics

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<th>Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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</table>

Abstract

Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various material models.

Objective

Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can often only be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

Content

1 Introduction to (numeric) forensic engineering
2 The nature of engineering problems (governing equations)
3 Numerical recipes for dealing with non-linear problems
4 Multi-field problems (HTM)
5 Creep and relaxation
6 On the nature of failure - Physics of damage and fracture
7 Cracks and growth in structures (LEFM and beyond)
8 Damage and fracture in heterogeneous materials
9 Mechanics of fatigue
10 Student -Project presentation

Lecture notes

Will be provided during the lecture via moodle.

Literature

Will be provided during the lecture.
Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn how to solve diffusion, wave propagation and advection processes;
- Implement efficient iterative algorithms;
- Get started with software development tools: git, version control.

Part 2 - Developing your own parallel algorithms on GPUs
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Understand the practical challenges of parallel computing: GPUs, multi-core CPUs;
- Learn about main simulation performance limits;
- Implement software development tooling: unit tests, continuous integration (CI).

Part 3 - Multi-GPU computing projects
- Understand the practical challenges of distributed parallel computing on multi-GPUs;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPUs);
- Automate the software tooling using remote runners.

Final projects
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites / notice
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
Social Competencies
- Communication
Personal Competencies
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

101-0139-00L  Scientific Machine and Deep Learning for Design and Construction
W  3 credits  4G  B. Bickel, A. Müller, M. Piovarci

Abstract
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

Objective
This course aims to provide a graduate-level introduction to machine learning, with a particular focus on scientific machine learning for applications in the design and construction phases of projects from architecture and civil engineering.

Upon completion of the course, the students will be able to:
1. Understand main ML background theory and methods.
2. Assess a problem and apply ML and DL in a computational framework accordingly.
3. Incorporate scientific domain knowledge in the SciML process.
4. Define, plan, conduct and present a SciML project.
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
2. Incorporation of Domain Knowledge into ML and DL.
4. ML training, validation and testing pipelines for academic and research projects.

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Suggested Reading:
- Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning

Familiarity with Python is advised.

The course gives an introduction to structural glass design and related façade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.

After successful completion of the course, students will be able to:
- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;
- Recognize requirements for glass elements depending on their application area and chose the appropriate glass products and assemblies accordingly;
- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;
- Apply selected approaches for the structural design of in-plane loaded glass elements;
- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.

This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent façades.

The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

The lectures are based on lecture slides and handouts.

Recommended and supplementary literature:

Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.
### Microscopic Modelling and Simulation of Traffic Operations

**W 3 credits 2G M. Makridis**

**Abstract**
The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic engineering project from beginning to end.

**Objective**
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties, modeling and simulation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

**Content**
In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.

Microscopic modelling and simulation concepts will include:
1. Car following models
2. Lane change models
3. Calibration and validation methodology

Specific tasks for the project will include:
1. Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2. Calibrating and validating the simulation model.
3. Redesiging/extend the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term used for the presentation of the work will be asked from each group of students.

It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

**Literature**
The lecture notes and additional handouts will be provided before the lectures.

**Prerequisites / notice**
Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

**Competencies**

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<thead>
<tr>
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<th>Subject-specific Competencies</th>
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<td>Critical Thinking</td>
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<td>Techniques and Technologies</td>
<td>Media and Digital Technologies</td>
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**102-0468-10L Watershed Modelling**

W 6 credits 4G P. Molnar, A. Costa, S. Sinclair

**Abstract**
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

**Objective**
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

**Content**
The first part (A) of the course is on watershed properties analyzed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance metrics in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focused on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

**Lecture notes**
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

**Literature**
Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 220 of 2667
Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences). Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Method-specific Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management


101-0491-10L
Basics of Java and Best Practices for Scientific Computing
W 1 credit 1U M. Balac

Abstract
This course provides an introduction to programming in Java, version control, and cloud computing.

Objective
At the end of the course, the students should
- Have acquired object-oriented programming skills with a focus on Java.
- Have an understanding of version control using git
- Have learned to deploy java applications on servers

Content
This course provides an introduction to object-oriented programming with Java. Four topics are covered:
- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods,...)
- Injection (traditional vs. Guice)
- Code versioning
- Java application deployment on servers

Literature
Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang

401-0647-00L
Introduction to Mathematical Optimization
W 5 credits 2V+1U D. Adjiashvili

Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

Objective
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Literature
Information about relevant literature will be given in the lecture.

Prerequisites / notice
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

101-0307-00L
Design and Construction in Geotechnical Engineering
W 4 credits 3G I. Anastasopoulos, K. Kassas, A. Marin, L. Sakellariadis

Abstract
This lecture deals with the practical application of the knowledge gained in the fundamental lectures from the Bachelor degree. The basics of planning and design of geotechnical structures will be taught for the main topics geotechnical engineers are faced to in practice.

Objective
Transfer of the fundamental knowledge taught in the Bachelor degree to practical application.

Ability to plan and design geotechnical structures based on the state of the art.

Content
- Introduction to Swisscode SIA
- Foundations and settlements
- Pile foundations
- Excavations
- Slopes
- Soil nailing
- Reinforced geosystems
- Ground improvement
- River levees

Lecture notes
Script in the form of chapters and powerpoint overheads with web support (moodle-app2.let.ethz.ch)

Exercises

Literature
Relevant literature will be stated during the lectures

Prerequisites / notice
Pre-condition: Successful examinations (pass) in the geotechnical studies (soil mechanics and ground engineering, each 5 credits) in the Bachelor degree of Civil Engineering (ETH), or equivalent for new students.

The lecture contains at least one presentation from practice.
In this course students will see what the BIM method entails for a civil engineer and learn how to create a parametric model yourself incl. associated steel, precast concrete, in-situ concrete, reinforcement and masonry parts based on a practical example. Students will also learn how to automatically create formwork plans, parts lists and data for digital prefabrication and construction sites. They will thus acquire the necessary basis for their future work as engineers and how their work interacts with draughtsmen, designers and master builders in a digital working environment.

In this course, students will see what the BIM method entails for a civil engineer and learn how to create a parametric model yourself inclusive of associated steel, precast concrete, in-situ concrete, reinforcement and masonry parts based on a practical example. Students will also learn how to automatically create formwork plans, parts lists and data for digital prefabrication and construction sites. They will thus acquire the necessary basis for their future work as engineers and how their work interacts with draughtsmen, designers and master builders in a digital working environment.

This course aims to provide a basic understanding of the mechanics and rheology of granular matter. It includes fundamental concepts as well as recent progress in research with main focus on related engineering and natural hazards applications. Small experiments are performed in class to illustrate important processes and state-of-the-art numerical modeling tools are introduced and used.

Granular materials have the ability to sustain stresses like a solid of flow like a fluid depending on the applied solicitation and boundary conditions. This course targets civil, geotechnical and mechanical engineering students, who are interested in discovering the fascinating and sometimes surprising world of granular media, the second most used material in industry and in learning novel modeling approaches. After this class, the students should know how to describe inter-particle interactions at the grain scale, the statics of granular materials, the transition towards fluid states through classical frictional plastic laws and the rheology of granular flows. Furthermore, the students should know the basics of the Discrete Element Method (DEM), its advantages and limitations and should be able to use a commercial software for different types of application.

This course will not cover aspects related to granular gasses and kinetic theory. This course covers grain-scale interactions, statics and rheology of granular materials based on a mix between classical lectures, on-board developments, presentation of small experiments, analytical and numerical exercises. We present the domains of application of granular mechanics through examples taken from the industry or research. In addition, the Discrete Element Method (DEM) together with state-of-the-art contact models will be presented and used to simulate standard tests such as the granular column collapse, shear flows but also more complex industrial or geophysical problems. Calibration of model parameters based on laboratory experiments will be discussed. The course will not cover aspects related to granular gasses and kinetic theory.

Practice-oriented introduction to BIM working methods for civil engineers. Advantageous applications compared to 2D/3D, especially for digital construction and parametric modelling.

Basic knowledge of physics, mechanics and soil mechanics is required.

- Parametric modelling of steel, precast concrete, in-situ concrete, reinforcements and masonry
- Parametric modelling of connections and joints
- Defining and evaluating concreting stages
- Semi-automatic creation of formwork plans according to sia standards
- Automatic export of all necessary models and data for BIM2Field
- Insight into BIM2Field applications "Stake out from model" and "Lay reinforcement based on model".

Available eLearning content
PowerPoint slides

Lecture notes

Prerequisites / notice
Basic knowledge of construction detailing in steel and concrete, as taught in the BSc courses for steel and concrete structures, is of advantage.

This course will not cover aspects related to granular gasses and kinetic theory.

Basic knowledge of physics, mechanics and soil mechanics is required.
Bridge Design: Project Competition

W. Kaufmann

Abstract
This module offers the possibility to apply the fundamentals of the course Bridge Design in a conceptual design project. The scenario is set as a design competition: The students (group of two) will get a basic documentation (service criteria agreement, plans, digital terrain model, geotechnical report, photo documentation, etc.) and will develop a conceptual design suitable for the given site.

Objective
At the end of the course, students will have developed a convincing bridge design that satisfies following criteria:
1. Consideration of governing boundary conditions and constraints.
2. Conception of an efficient structural system with an adequate aesthetic expression considering the environment.
3. Definition of the relevant actions and decisive load cases.
4. Proof of feasibility by dimensioning the main structural elements.
5. Schematic overview of construction processes.
6. Appropriate presentation and visualisation of the proposed bridge design.

Content
The module is built up as follows:
0. Presentation of problem statement / project. (1st week of semester)
1. Introduction to design tools & working methods.
2. Working on project (milestones):
   a. Define requirements and boundary conditions.
   b. Study of references and possible concepts.
   c. Choice of best variant.
   d. Structural modelling & calculations.
   e. Plans & visualisation.
3. Presentation of your work in a mid-term and a final critique.
4. Submission.

Prerequisites / notice
101-0138-00L Bridge Design or an equivalent attestation of knowledge in bridge design.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Digital Creativity for Circular Construction

C. De Wolf

Abstract
The course is about digital innovation towards a circular economy in the built environment. How can we bring together two worlds that are often too distinct: low-impact construction and digital innovation? Bringing digital tools already used in other sectors into the construction sector, students will learn about circular construction (e.g., reuse of materials) through hands-on learning practices.

Objective
In the fall semester 2024 we will focus on applying artificial intelligence (AI) and extended reality (XR) to the circular design workflow and. The course will be taught at the Kunsthalle Zurich as part of an exhibition.

By the end of this course, students will be able to use augmented computational design enabling circular construction, with a view to environmental implications. They will be able to assess the challenges and opportunities of low-carbon, circular construction and evaluate possible solutions using digital technologies to enable a circular built environment (more specifically, with reused building materials). To achieve this, they need to be able to do the following:
1. Apply circular principles using recovered building materials.
2. Compare different digital technologies applied in circular construction (e.g., LiDAR scanning, drone imagery, photogrammetry, computational design, AI, computer vision, XR, LCA tools etc.)
3. Understand the potential and limitations of AI for circular construction, e.g. use machine learning to detect and digitize materials (computer vision) or to support creativity in the early design phases of circular construction (generative AI).
4. Communicate the importance and urgency of circular construction.
5. Assess the environmental impact implications of their design and technology decisions through a preliminary Life Cycle Assessment (LCA).

Content
Students will receive an introduction to circular principles by experts from the building industry and visit of (de-)construction sites where circular construction is exemplified. They will explore how to use digital technologies such as LiDAR scanning, photogrammetry, scan-to-BIM, computer vision, computational design, digital fabrication, blockchain technology and learn about the design implications using reclaimed building materials. This course is meant as an overview/introduction of many digital technologies that could be useful for circularity and gives the tools to students to further study the technologies they are most interested in on their own. Creativity in writing, filmmaking, design, construction, etc. is expected from the students. This course will give the tools to students to learn more on LCA if they wish to deepen their knowledge further.

Lecture notes
Language: English
Courses are on Tuesday afternoons in Kunsthalle or a room at ETH, but also require out-of-the-semester work and significant homework and site visits outside of class hours.
Hydraulic Engineering III

**Prerequisites / notice**
Interest in Digitalisation and Construction. Flexibility: This is a hands-on course, where students explore digital technologies and opportunities/challenges of reuse. Flexibility (e.g. adapting to unforeseen circumstances), responsibility (e.g. arriving on time for safety briefing), and spontaneity (e.g. finding innovative solutions) is expected from the students to adapt to the contingencies from demolition and construction sites with reused materials. The course is mandatory for MIBS students. If you are a first-year MIBS student, please do not apply, you are automatically accepted. All other students from other departments should apply. Please only register for the course if you really intend to participate on all course dates (see course catalog). Please only register for the course if you are willing to send us a letter of motivation and really intend to participate; otherwise, you will deprive someone else of a place. All non-MIBS students who register go onto a waiting list until 11.09.2024 and up to 25 of them will be selected by the lecturer.

To register:
1. Enroll before 05.09.2024.
2. Send a short letter of motivation (max. 300 words) and a 1-page CV to cea-course@ibi.baug.ethz.ch by 05.09.2024.

**Collaborators:** Kunsthalle Zürich, ETH AI Center, Design++

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
101-0249-00L | Hydraulic Engineering III | W | 3 credits | 2S | R. Boes

**Abstract**
The lecture focuses on selected topics in hydraulic engineering, water management and aquatic ecology relating to hydropower and flood protection projects.

**Objective**
The overarching goal of the course is to broaden and enhance knowledge on special aspects in hydraulic engineering and its links to aquatic ecology and to understand the procedures and the planning sequence of large-scale projects.

**Content**
Selected topics in hydraulic engineering will be focused on, e.g. dam safety, materials in dam construction, possible problems at reservoirs like hazards from impulse waves and dam breaching, the hydraulics of spillways and intake structures at dams and weirs and the link between hydropower and ecology. Another focus will be put on typical approaches and procedures in the planning process of large-scale hydraulic engineering projects at the national and international level.

**Lecture notes**
Lecture handouts will be available online. Parts of the lectures will also be covered by a manuscript that will be available in electronic form.

**Literature**
will be specified in the lecture and in a written manuscript

**Prerequisites / notice**
External speakers will be involved to present current topics and projects in Switzerland and abroad.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: assessed

**Personal Competencies**
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

101-0608-00L

**Design-Integrated Life Cycle Assessment**

**Abstract**
Currently, Life Cycle Assessment (LCA) is applied as an ex-post design evaluation of buildings, but rarely used to improve the building during the design process. The aim of this course is to apply LCA during the design of buildings by means of a digital, parametric tool. The necessary fundamentals of the LCA method will be taught following a lecture on demands approach.
The course will follow two main objectives and a third optional objective, depending on the design projects the students' choose. At the end of the course, the students will:

1. Know the methodology of LCA
2. Be able to apply LCA in the design process to assess and improve the environmental performance of their projects
3. Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation
4. Assess and improve the environmental performance of their projects
5. Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation

The course will be structured into two parts, each making up about half of the semester.

Part I: Exercises with lectures on demand
The first six individual courses will follow the "lectures on demand" approach. Small "hands-on" exercises focusing on one specific aspect will be given out and the necessary background knowledge will be provided in the form of short input lectures when questions arise. The following topics will be discussed during the first part:

1) LCA basic introduction
2) System boundaries, functional unit, end of life
3) Decision-making
4) Media and Digital Technologies
5) Problem-solving
6) Integrated assessment tools (ladybug tools)
7) Introduction to in-house grasshopper plugin for LCA analysis

Part II: Project-based learning
In the second part, the students will work on their individual project in groups of three. For the design task, the students will bring their own project and work on improving it. The projects can be chosen depending on the students background and range from buildings to infrastructure projects. Intermediate presentations will ensure the continuous work and make sure all groups are on the same level and learn from each other. During this part, the following hands-on tutorials will be given:

1) Introduction to Rhinoceros 6 and 7
2) Introduction to grasshopper
3) Integrated assessment tools (ladybug tools)
4) Introduction to in-house grasshopper plugin for LCA analysis

Lecture notes
As the course follows a lecture on demand approach, the lecture slides will be provided after each course.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

Prerequisites / notice
The students are expected to work out of class as well. The course time will be used by the teachers to answer project-specific questions.

The lecture series will be conducted in English and is aimed at students of master's programs, particularly in civil engineering and MIBS. No lecture will be given during Seminar week.

Competencies
Subject-specific Competencies
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Sensitivity to Diversity fostered
Negotiation fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection assessed

101-0329-00L  Tunnelling III  W  4 credits  2G  G. Anagnostou, E. Pimentel, M. Ramoni

Abstract
Deepen the knowledge on selected topics of underground construction as well as learning working out conceptual solutions of complex problems.

Objective
Lecture: Deepen the knowledge on selected topics of underground construction.
Exercises: Conceptual solutions of complex problems.

Content
Caverns: Geometry, construction methods, support.
Shafts: Construction methods, support.
Urban tunnelling: Boundary conditions, system choice, alignment, design.
Field measurements: Principles, monitoring layout, applications, interpretation.
Cut and cover tunnels: Modelling, design.
Exercising conceptual solution of complex tunnelling problems based upon discussion of current tunnel cases with particularly demanding problems in small groups.

Lecture notes
Autographieblätter

Prerequisites / notice
Prerequisite: BSc course "Tunnelling", MSc courses "Tunnelling I" and "Tunnelling II".

This course will continue to be offered in German up to and including HS24.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

101-0139-00L  Scientific Machine and Deep Learning for Design and Construction  W  3 credits  4G  B. Bickel, A. Müller, M. Piovarci

Abstract
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.
Objective
This course aims to provide a graduate-level introduction to machine learning, with a particular focus on scientific machine learning for applications in the design and construction phases of projects from architecture and civil engineering.

Upon completion of the course, the students will be able to:
1. Understand main ML background theory and methods.
2. Assess a problem and apply ML and DL in a computational framework accordingly.
3. Incorporate scientific domain knowledge in the SciML process.
4. Define, plan, conduct and present a SciML project.

Content
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
2. Incorporation of Domain Knowledge into ML and DL.
4. ML training, validation and testing pipelines for academic and research projects.

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

Lecture notes
The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Literature
Suggested Reading:
- Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
- S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016

Prerequisites / notice
Familiarity with Python is advised.

Competencies
Subject-specific Competencies
Concepts and Theories 
Techniques and Technologies 
Method-specific Competencies
Analytical Competencies 
Decision-making 
Media and Digital Technologies 
Problem-solving 
Project Management 
Social Competencies
Communication 
Cooperation and Teamwork 
Personal Competencies
Creative Thinking 
Critical Thinking 
Self-direction and Self-management

101-0357-00L
Theoretical and Experimental Soil Mechanics ■

Prerequisites: Mechanics I, II and III.

The number of participants is limited to 60 due to the existing laboratory equipment! Students with major in Geotechnical Engineering have priority. Registrations will be accepted in the order they are received.

Abstract
Overview of soil behaviour
Explanation of typical applications: reality, modelling, lab tests with transfer of results to practical examples
Consolidation theory and typical applications
Triaxial tests: consolidation & shear, drained & undrained response
Plasticity theory & Critical State Soil Mechanics, Cam Clay
Application of plasticity theory
Introduction to physical modelling

Objective
(1) Extend knowledge of theoretical approaches that can be used to describe soil behaviour.
(2) Offer the opportunity to perform hands on element tests required for constitutive model calibration.
(3) Enable students to select an appropriate constitutive model and calibrate it using element test performed in the lab.
(4) Enable students to carry out FE analyses for realistic geotechnical applications.

Content
Overview of soil behaviour
Discussion of general gaps between basic theory and soil response
Stress paths in practice & in laboratory tests
Explanation of typical applications: reality, modelling, laboratory tests with transfer of results to the practical examples
Consolidation theory for incremental and continuous loading oedometer tests and typical applications in practice
Triaxial & direct shear tests: consolidation & shear, drained & undrained response
Plasticity theory & Critical State Soil Mechanics, Cam Clay
Application of plasticity theory
Introduction to physical modelling with emphasis on centrifuge modelling

Lecture notes
Printed script with web support
Exercises

Literature
https://moodle-app2.let.ethz.ch/

Pre-requisites: Fundamental knowledge of solid and soil mechanics.

The theoretical part of the course will be covered by problem-based lectures.
The experimental part will be covered by hands-on element tests performed by the students in the laboratory. These experimental results will be instrumental in the calibration of advanced soil constitutive models.
The connection between the experimental and theoretical parts of the course will be facilitated by means of numerical investigations (i.e, FE analyses), including the selection and calibration of relevant constitutive models. The numerical investigations shall be documented by the students in a final report.

Laboratory equipment will be available for 60 students. Students registered for the Geotechnics Specialty in Masters will be given priority as follows: (1) 2nd year students; (2) 1st year students, (3) doctoral students taking the class for their qualifying exam; Further students will be admitted on a first-come-first-served basis.
Structural Glass Design and Facade Engineering

Abstract
The course gives an introduction to structural glass design and related façade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.

Objective
After successful completion of the course, students will be able to:
- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;
- Recognize requirements for glass elements depending on their application area and chose the appropriate glass products and assemblies accordingly;
- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;
- Apply selected approaches for the structural design of in-plane loaded glass elements;
- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.

Content
This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

Lectures:
The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Topologies and design of structural systems for transparent façades;
- Requirements and functions for transparent façades.

Design exercises:
The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Design project:
The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

Lecture notes
The lectures are based on lecture slides and handouts.

Literature
Recommended and supplementary literature:

Prerequisites / notice
Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: fostered

Solving Partial Differential Equations in Parallel on GPUs

Abstract
This course aims to cover state-of-the-art methods in modern parallel computing on Graphics Processing Unit (GPU), supercomputing and code development with applications to natural sciences and engineering.

Objective
When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraged on parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.
Communication
The course is based on the book
Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn how to solve diffusion, wave propagation and advection processes;
- Implement efficient iterative algorithms;
- Get started with software development tools: git, version control.

Part 2 - Developing your own parallel algorithms on GPUs
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Understand the practical challenges of parallel computing: GPUs, multi-core CPUs;
- Learn about main simulation performance limiters;
- Implement software development tooling: unit tests, continuous integration (CI).

Part 3 - Multi-GPU computing projects
- Understand the practical challenges of distributed parallel computing on multi-GPUs;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPUs);
- Automate the software tooling using remote runners.

Final projects
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites / notice
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management assessed

101-0659-01L
Durability and Maintenance of Reinforced Concrete W 4 credits 2V U. Angst, Z. Zhang

Abstract
We look at the durability of reinforced concrete structures, covering common deterioration processes such as reinforcement corrosion, frost damage, ASR, etc. The course spans the range from fundamental mechanisms to aspects of engineering practice. New methods and materials for preventative measures, condition assessment and repair techniques are treated. Examples from real cases are shown.

Objective
After this course you will have profound understanding about:

- the different mechanisms of deterioration of concrete structures, in particular reinforcement corrosion
- the relevant parameters affecting durability of reinforced concrete (cover depth, concrete quality, moisture, etc.)

Furthermore, you will know:

- current engineering approaches for durability design (accoring to standards) and their limitations
- refined models for enhanced durability design and service life predictions
- preventive measures to improve durability (e.g. stainless steel reinforcement, concrete surface coatings, etc.)
- the particular durability challenges with post-tensioned structures and ways to overcome them (electrically isolated tendons)
- methods for inspection and condition assessment of existing, ageing structures (including non-destructive techniques and monitoring with sensors)
- repair methods for deteriorated concrete structures such as conventional repair and electrochemical methods (in particular cathodic protection)
- possible future problems for durability that may arise with modern materials and construction technologies
- Socio-economic challenges related to ageing infrastructures
- Degradation mechanisms for concrete: sulphate attack, ASR, frost attack.
- Inspection and condition assessment: Chloride analyses, carbonation depth, etc. Non-destructive tests, particularly potential mapping to detect corrosion. New developments (for example, monitoring with sensors).
- Stainless steel as reinforcing steel for concrete: Different types of stainless steels. Coupling with black reinforcing steel. Examples of application. Life-cycle-costs.
- Modern materials and construction technologies: Discussion of expected implications for the durability of structures today and in the future.

Excursion:
- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

The course is based on the book

Slides of the lectures will be distributed in advance
Special handouts and reprints for particular topics will be distributed
The course is based on the book

Slides of the lectures will be distributed in advance

Special handouts and reprints for particular topics will be distributed

Form of teaching:
The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

Report:
Each student will work on a small case study and deliver a report during the semester. The report will be graded.

Excursion:
We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Competencies

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| Social Competencies                 |          |
| Communication                       | assessed |
| Cooperation and Teamwork            | assessed |
| Customer Orientation                | fostered |
| Leadership and Responsibility       | fostered |
| Self-presentation and Social Influence | fostered |
| Sensitivity to Diversity            | fostered |
| Negotiation                         | fostered |

| Personal Competencies               |          |
| Adaptable and Flexibility           | fostered |
| Creative Thinking                   | assessed |
| Critical Thinking                   | assessed |
| Integrity and Work Ethics           | assessed |
| Self-awareness and Self-reflection  | fostered |
| Self-direction and Self-management  | assessed |

101-0677-00L  Concrete Technology  W  2 credits  2G  F. Nägele, G. Martinola, T. Wangler

Abstract
Opportunities and limitations of concrete technology.
Commodities and leading edge specialties.

Objective
Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.

Content
Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as: self compacting concrete, fiber reinforced concrete, fast setting concrete
- the role of sustainability in concrete technology
- new research in digital fabrication with concrete

Lecture notes
Slides provided for download.

Competencies

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101-0427-01L  Public Transport Design and Operations  W  6 credits  4G  F. Corman

Abstract
This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.
Objective

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies,
system design and line planning for different situations,
timetabling and tactical planning, and related mathematical approaches
operations, and quantitative support to operational problems,
evaluation of public transport systems.

Content

Basics for line transport systems and networks
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes

Lecture slides are provided.

Literature

Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

101-0492-00L Microscopic Modelling and Simulation of Traffic Operations W 3 credits 2G M. Makridis

Abstract

The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.
Objective

The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.

Microscopic modelling and simulation concepts will include:
1) Car following models
2) Lane change models
3) Calibration and validation methodology
Specific tasks for the project will include:
1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/ extending the model to improve the traffic performance through Aimsun and with/ without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and present) across the semester. A mid-term and final presentation of the work will be asked from each group of students.

The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Lecture notes

The lecture notes and additional handouts will be provided before the lectures.

Literature

Additional literature recommendations will be provided at the lectures.

Prerequisites / notice

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Media and Digital Technologies fostered
- Problem-solving fostered

Social Competencies
- Cooperation and Teamwork assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed

101-0527-10L Materials and Constructions W 4 credits 2G G. Habert, M. Posani

Abstract

Building materials with a special focus on regenerative materials: earth, bio-based and reuse.
Looking at material sourcing, properties and performance, as well as how they are integrated in the buildings (building envelope and detailing).
Choice of material is done out of sustainability concern.
Comfort, moisture transfer and building physics with hygroscopic materials.

Objective

Special focus on regenerative materials: earth, bio-based and reuse
The students will acquire knowledge in the following fields:
Fundamentals of material performance
Introduction to durability problems of building facades
Materials for the building envelope:
- Overview of structural materials and systems: concrete, steel, stone, earth, wood and bamboo
- Insulating materials (bio-based vs conventional)

Assessment of materials and components behaviour and performance
Degradation risks connected to insulation and post-insulation
Aspects of sustainability and durability

Special focus on comfort, moisture transfer and building physics with hygroscopic materials will be done.

Content

Introduction
Sustainable cement and concrete
Earth construction
Stone
Steel
Bamboo
Timber construction
Building physic and conventional insulation
Bio-based insulation and degradation risks with insulation
Hygrothermal properties of building materials and dynamic numerical simulations
Efficiency and sustainability of modern window glazing

Course will have general lectures
+ hands on lab @home experiments
+ group project for implementation of regenerative materials.
### 101-0123-00L Structural Design

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<th>Competencies</th>
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<th>Techniques and Technologies</th>
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<td>Self-awareness and Self-reflection</td>
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**Objective:**
After a successful completion of the course, students will be able to:

1. Critically evaluate structural design concepts based on their impact and implications beyond the sole structural performance
2. Identify the most relevant design parameters and performance criteria for a given design task and select adequate tools to effectively integrate them as part of the design process
3. Develop structural systems in compliance with structural, spatial, and environmental design aspects simultaneously

**Abstract:**
The goal of the course is to introduce students to Structural Design. The course fosters the development of a design thinking that emerges from the coexistence of a number of design parameters and performance criteria related to force flow, construction technologies, material use, and spatial qualities.

### 101-0267-01L Numerical Hydraulics

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**Objective:**
In the course Numerical Hydraulics the basics of numerical modelling of flows are presented.

**Abstract:**
The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.

**Content:**
The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

**Lecture notes:**
Slides from the lectures and programs used can be downloaded.

### 101-0186-01L BIM, Parametric Modeling and Digital Construction for Civil Engineers

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<th>Competencies</th>
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**Objective:**
Practice-oriented introduction to BIM working methods for civil engineers.

**Abstract:**
Advantageous applications compared to 2D/3D, especially for digital construction and parametric modelling.

**Content:**
- Parametric modelling of steel, precast concrete, in-situ concrete, reinforcements and masonry
- Parametric modelling of connections and joints
- Defining and evaluating concreting stages
- Semi-automatic creation of formwork plans according to sia standards
- Automatic export of all necessary models and data for BIM2Field
- Insight into BIM2Field applications "Stake out from model" and "Lay reinforcement based on model".

**Lecture notes:**
Available eLearning content

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Data: 02.07.2024 12:39
This course covers grain-scale interactions, statics and rheology of granular materials based on a mix between classical lectures, on-board lectures and laboratory experiments.

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies
- Media and Digital Technologies
- Cooperation and Teamwork

**Competencies**
- Subject-specific Competencies: assessed
- Method-specific Competencies: fostered
- Social Competencies: fostered

**Prerequisites / notice**
- Basic knowledge of construction detailing in steel and concrete, as taught in the BSc courses for steel and concrete structures, is of advantage.

**Literature**

**Prerequisites / notice**
- Basic knowledge of physics, mechanics and soil mechanics is required.

**Objective**
The goal is for students to familiarize themselves with the handling of assessment and rehabilitation of existing structures from the perspective of a consulting engineer, following a systematic approach as described in current codes and to further learn how to use new non destructive evaluation technologies.

**Content**
This course is organized in two main pillars. The first pillar describes the technologies that are available for non destructive evaluation of structures and delves into description of the principle of operation of such methods (e.g. wave propagation, acoustic emission analysis, tomography). The second pillar, overviews the current implementation of condition assessment processes in codes and standards, Complementary to the topic of structural evaluation, the topic of interventions, rehabilitation and retrofitting of existing structures for different construction materials is next addressed.

**Lecture notes**
Lecture notes

**Books**
1. Granular Media: Between Fluid and Solid by Bruno Andreotti, Olivier Pouliquen, and Yoël Forterre
2. Particulate Discrete Element Modelling: A Geomechanics Perspective by Catherine O'Sullivan

**Prerequisites / notice**
- Basic knowledge of physics, mechanics and soil mechanics is required.
W. Kaufmann

Subject-specific Competencies

Concepts and Theories 
Techniques and Technologies

Method-specific Competencies

Analytical Competencies 
Media and Digital Technologies

Social Competencies

Communication 
Cooperation and Teamwork

Personal Competencies

Creative Thinking 
Critical Thinking

101-0138-11L Bridge Design: Project Competition

W 4 credits 2S W. Kaufmann

Abstract

This module offers the possibility to apply the fundamentals of the course Bridge Design in a conceptual design project. The scenario is set as a design competition: The students (group of two) will get a basic documentation (service criteria agreement, plans, digital terrain model, geotechnical report, photo documentation, etc.) and will develop a conceptual design suitable for the given site.

Objective

At the end of the course, students will have developed a convincing bridge design that satisfies following criteria:

- Consideration of governing boundary conditions and constraints.
- Conception of an efficient structural system with an adequate aesthetic expression considering the environment.
- Definition of the relevant actions and decisive load cases.
- Proof of feasibility by dimensioning the main structural elements.
- Schematic overview of construction processes.
- Appropriate presentation and visualisation of the proposed bridge design.

Content

The module is built up as follows:

0. Presentation of problem statement / project. (1st week of semester)
1. Introduction to design tools & working methods.
2. Working on project (milestones):
   - a. Define requirements and boundary conditions.
   - b. Study of references and possible concepts
   - c. Choice of best variant
   - d. Structural modelling & calculations
   - e. Plans & visualisation
3. Presentation of your work in a mid-term and a final critique.
4. Submission

Prerequisites / notice

101-0138-00L Bridge Design or an equivalent attestation of knowledge in bridge design.

Competencies

Subject-specific Competencies

Concepts and Theories 
Techniques and Technologies

Method-specific Competencies

Analytical Competencies 
Media and Digital Technologies

Social Competencies

Communication 
Cooperation and Teamwork

Personal Competencies

Adaptability and Flexibility 
Creative Thinking

101-0531-00L Digital Creativity for Circular Construction

W 8 credits 7SP C. De Wolf

Abstract

The course is about digital innovation towards a circular economy in the built environment. How can we bring together two worlds that are often too distinct: low-impact construction and digital innovation? Bringing digital tools already used in other sectors into the construction sector, students will learn about circular construction (e.g., reuse of materials) through hands-on learning practices.

Objective

In the fall semester 2024 we will focus on applying artificial intelligence (AI) and extended reality (XR) to the circular design workflow and. The course will be taught at the Kunsthalle Zurich as part of an exhibition.

The course is about digital innovation towards a circular economy in the built environment. How can we bring together two worlds that are often too distinct: low-impact construction and digital innovation? Bringing digital tools already used in other sectors into the construction sector, students will learn about circular construction (e.g., reuse of materials) through hands-on learning practices.

By the end of this course, students will be able to use augmented computational design enabling circular construction, with a view to environmental implications. They will be able to assess the challenges and opportunities of low-carbon, circular construction and evaluate possible solutions using digital technologies to enable a circular built environment (more specifically, with reused building materials). To achieve this, they need to be able to do the following:

1. Apply circular principles using recovered building materials.
2. Compare different digital technologies applied in circular construction (e.g., LiDAR scanning, drone imagery, photogrammetry, computational design, AI, computer vision, XR, LCA tools etc.)
3. Understand the potential and limitations of AI for circular construction, e.g., use machine learning to detect and digitize materials (computer vision) or to support creativity in the early design phases of circular construction (generative AI).
4. Communicate the importance and urgency of circular construction.
5. Assess the environmental impact implications of their design and technology decisions through a preliminary Life Cycle Assessment (LCA).
Students will receive an introduction to circular principles by experts from the building industry and visit of (de-)construction sites where circular construction is exemplified. They will explore how to use digital technologies such as LiDAR scanning, photogrammetry, scan-to-BIM, computer vision, computational design, digital fabrication, blockchain technology and learn about the design implications using reclaimed building materials. This course is meant as an overview/introduction of many digital technologies that could be useful for circularity and gives the tools to students to further study the technologies they are most interested in on their own. Creativity in writing, filmmaking, design, construction, etc. is expected from the students. This course will give the tools to students to learn more on LCA if they wish to deepen their knowledge further.

Courses are on Tuesday afternoons in Kunsthalle or a room at ETH, but also require out-of-the-semester work and significant homework and site visits outside of class hours.

Interest in Digitalisation and Construction. Flexibility: This is a hands-on course, where students explore digital technologies and opportunities/challenges of reuse. Flexibility (e.g. adapting to unforeseen circumstances), responsibility (e.g. arriving on time for safety briefing), and spontaneity (e.g. finding innovative solutions) is expected from the students to adapt to the contingencies from demolition and construction sites with reused materials. The course is mandatory for MIBS students. If you are a first year MIBS student, please do not apply, you are automatically accepted. All other students from other departments should apply. Please only register for the course if you really intend to participate on all course dates (see course catalog). Please only register for the course if you are willing to send us a letter of motivation and really intend to participate; otherwise, you will deprive someone else of a place. All non-MIBS students who register go onto a waiting list until 11.09.2024 and up to 25 of them will be selected by the lecturer.

To register:
1. Enroll before 05.09.2024.
2. Send a short letter of motivation (max. 300 words) and a 1-page CV to cea-course@ibi.baug.ethz.ch by 05.09.2024.

Collaborators: Kunsthalle Zürich, ETH AI Center, Design++

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<th>Personal Competencies</th>
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<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Project Management</td>
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<td>Media and Digital Technologies</td>
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**Master’s Thesis**

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<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>43D</td>
<td>Supervisors</td>
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Only students who fulfill the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract

The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen specialisations and has to be completed within 18 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective

To work independently and to produce a scientifically structured work.

Content

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

**Master’s Thesis (ONLY for Programme Regulations 2006)**

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<th>Number</th>
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Only students who fulfill the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to
gain admission to the master programme.

Abstract
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective
To work independently and to produce a scientifically structured work.

Content
The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

Electives
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Electives ETH Zurich
The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

Recommended Electives of Master Programme

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<td>H. Klumpner</td>
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<td>F. T. Salva Rocha Franco</td>
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Abstract
Students are introduced to a narrative of ‘Urban Stories’ through a series of three tools driven by social, governance, and environmental transformations in today’s urbanization processes. Each lecture explores one city’s spatial and organizational ingenuity born out of a particular place's realities, allowing students to transfer these inventions into a catalog of conceptual tools.

Objective
How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. How do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.

Content
The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

Literature
Course slides will be made available to students prior to each class.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Communication: fostered
- Creative Thinking: fostered

Method-specific Competencies
- Critical Thinking: fostered

Social Competencies
- Communication: fostered

Personal Competencies
- Critical Thinking: fostered
Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

The elective course "Topology" in the Autumn Semester 2023 builds on a long-standing specialization in the spatial exploration of the landscape. We will embark the participants on a terrain that we shape through our own thoughts and actions, adopting different perceptual perspectives, supported by examples from art, literature, technology and history.

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<td>Critical Thinking</td>
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### Science in Perspective

*see Science in Perspective: Language Courses ETH/UZH*

*see Science in Perspective: Type A: Enhancement of Reflection Capability*

*Recommended Science in Perspective (Type B) for D-BAUG*

### Civil Engineering Master - Key for Type

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<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
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### Key for Hours

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<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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### ECTS

*European Credit Transfer and Accumulation System*

*Special students and auditors need special permission from the lecturers.*
General Chemistry (Inorganic Chemistry) I

Abstract
Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions

Objective
Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective

Content
Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nerst equation, coordination chemistry, stepwise formation of metal complexes, solubility

Lecture notes
Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.

Literature

General Chemistry (Organic Chemistry) I

Abstract
Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions.

Objective
Introduction to the structures of organic compounds as well as the structural and energetic basis of organic chemistry.

Content

Lecture notes
Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt

Literature

General Chemistry (Physical Chemistry) I

Abstract
The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.

Objective
After the lecture, students will be able to,
- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- independently solve the Schrödinger equation for a molecular multi-particle system,
- to calculate quantitative properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- analyze and calculate absorption and emission spectra of single-electron atoms,
- to set up the Schrödinger equation for a molecular multi-particle system,
- to categorize the periodic table of elements with the help of the orbital concept,
- recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and
- establish term symbols for atomic ground states.

Content
Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger’s equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

Lecture notes
See homepage of the lecture.

Literature
See homepage of the lecture.

Prerequisites / notice
Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung.

Competencies

Fundamentals of Biology I: From Molecules to the Cell

Abstract
The lecture provides an introduction to some of the physical fundamentals of biology, in particular molecular biology, the structure of matter and an atom, the periodic table of elements, and chemical bonding.

Objective
After the lecture, students will be able to,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- independently solve the Schrödinger equation for a molecular multi-particle system,
- to calculate quantitative properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- analyze and calculate absorption and emission spectra of single-electron atoms,
- to set up the Schrödinger equation for a molecular multi-particle system,
- to categorize the periodic table of elements with the help of the orbital concept,
- recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and
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Content
Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger’s equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

Lecture notes
See homepage of the lecture.

Literature
See homepage of the lecture.

Prerequisites / notice
Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung.

Competencies
The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to foster a collection of slides and a script will be made available via Moodle.

The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts.

The newly conceived lecture is supported by scripts.


The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

The lecture notes are supported by scripts.

The literature is given in the lecture.

Further reading suggestions will be indicated during the lecture.

The lecture is divided into the following parts, which introduce the students to the chemistry of transition metals as well as lanthanides and actinides: 1) General definitions and terms in coordination chemistry; 2) Coordination numbers and structures; 3) Ligand types; 4) The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 5) The chemical bond in coordination compounds part B: Qualitative MO theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) Vibrational spectroscopy; 9) Electronic excitation.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories
  - assessed
- Techniques and Technologies
  - assessed

**Method-specific Competencies**
- Analytical Competencies
  - assessed
- Decision-making
  - fostered
- Media and Digital Technologies
  - fostered
- Problem-solving
  - assessed
- Project Management
  - fostered

**Social Competencies**
- Communication
  - fostered
- Cooperation and Teamwork
  - fostered
- Customer Orientation
  - fostered
- Leadership and Responsibility
  - fostered
- Self-presentation and Social Influence
  - fostered
- Sensitivity to Diversity
  - fostered
- Negotiation
  - fostered

**Personal Competencies**
- Adaptability and Flexibility
  - fostered
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - fostered
- Self-awareness and Self-reflection
  - fostered
- Self-direction and Self-management
  - fostered

**Literature**


**Lecture notes**

Will be provided

**Prerequisites / notice**

- Voraussetzungen:
  - Mathematik I und II
  - Allgemeine Chemie I und II
  - Physikalische Chemie I

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**Objective**

**Introduction to Chemical Reaction Kinetics**


**Content**

- Fundamental concepts: rate laws, elementary reactions and composite reactions, molecularity, reaction order. Experimental methods in reaction kinetics up to new developments in femtosecond kinetics. Simple chemical reaction rate theories: temperature dependence of the rate constant and Arrhenius equation, collision theory, reaction cross-section, transition state theory. Reaction mechanisms and complex kinetic systems, approximation techniques, chain reactions, explosions and detonations. Homogeneous catalysis and enzyme kinetics.

**Course objectives**

- Understand fundamental concepts of chemical reaction kinetics.
- Gain insight into reaction mechanisms and complex kinetic systems.
- Learn about homogeneous catalysis and enzyme kinetics.
- Study advanced topics such as explosion and detonation kinetics.

**Assessment**

- Contractual examination: 80% of the exam mark (in case of repetition of the exam, the exercise marks from a previous semester can be kept).
- Performance component: 12% of the exam mark.

**Information**

For more information about the lecture: www.csms.ethz.ch/education/InfoI

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**529-0422-00L**  
**Physical Chemistry II: Chemical Reaction Kinetics**

**Credit Distribution**

- 4 credits
- 3V+1U

**Objective**

- Introduction to Chemical Reaction Kinetics

**Content**

- Fundamental concepts: rate laws, elementary reactions and composite reactions, molecularity, reaction order. Experimental methods in reaction kinetics up to new developments in femtosecond kinetics. Simple chemical reaction rate theories: temperature dependence of the rate constant and Arrhenius equation, collision theory, reaction cross-section, transition state theory. Reaction mechanisms and complex kinetic systems, approximation techniques, chain reactions, explosions and detonations. Homogeneous catalysis and enzyme kinetics.

**Lecture notes**

Will be provided

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**529-0001-00L**  
**Introduction to Computer Science**

**Credit Distribution**

- 4 credits
- 2V+2U

**Objective**

- Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.
- Acquire a starting package concerning the computational aspects of natural sciences; discuss fundamentals of computer architecture, languages, algorithms and programming with an eye to their application in the area of chemistry, biology and material science.

**Content**

- Lecture: Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.
- Exercises: Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

**Prerequisites / notice**

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the written exam, the results of the exercises are taken into account when evaluating the results of the exam (compulsory performance component, 12% of the exam mark; in case of repetition of the exam, the exercise marks from a previous semester can be kept).

For more information about the lecture: www.csms.ethz.ch/education/InfoI

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**Organic Chemistry I**

**Credit Distribution**

- 3 credits
- 2V+1U

**Objective**

- This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.
- The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carbonyl acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.
### Content

### Literature

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<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
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<td>O</td>
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<td>D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi</td>
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<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi</td>
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### Examination Block III

#### Number Title Type ECTS Hours Lecturers
| 551-0307-00L | Molecular and Structural Biology I: Protein Structure and Function | O | 3 credits | 2V | R. Glockshuber, K. Locher, E. Weber-Ban |

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| 529-0731-00L | Nucleic Acids and Carbohydrates | O | 6 credits | 3G | K. Lang, M. Frei, P. A. Kast, H. Wennemers |

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### Prerequisites / notice
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.
Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Competencies

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Literature

529-0018-00L Organic Chemistry for Biochemistry and Chemical Biology

Objective
After the completion of this lecture, the students will have an understanding of organic chemistry commonly employed in the field of chemical biology, be able to apply these concepts to the design and synthesis of tools for probing biological pathways, and explain the underlying reaction mechanisms of selective reactions.

Content
The course will discuss past and recent advances in the synthesis of biomolecules, organic chemistry for applications in chemical biology, and the mechanism of relevant reactions. Topics will include chemical ligations, bioorthogonal reactions, photofunctional probes, photopharmacology, activity-based probes, targeted protein degraders, chemical probes for metabolites, fluorescent dyes and imaging, caged biomolecules, conditional activation, site-specific protein modification, and metabolic engineering.

Lecture notes
Lecture notes and other material relevant for the course will be available online under https://bode.ethz.ch/education.html.

Literature
Relevant research articles and review papers will be available in the course and course material.

Prerequisites / notice
This is an advanced organic chemistry course. Prior knowledge of organic synthesis, reactions, and mechanisms is required. Familiarity with biochemistry and biology is recommended.

Competencies

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Laboratory Courses

529-0124-00L BCB I: General Chemistry

Abstract
The general chemistry practical course aims at preparing the students for the work in modern chemistry laboratory. The students are trained to behave safely in the laboratory and use chemicals, chemistry glassware, and related equipment to perform and analyze the equilibrium in basic chemical reactions.

Objective
The students are expected to gain practical experience with as well as establish understanding of the following concepts and phenomena:

- Safe behavior and safety regulations in chemistry laboratory;
- Best practices in common techniques (purification, recrystallization, distillation, etc.);
- Analysis of measured values (measuring error, average value, error analysis);
- Acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems);
- Precipitation equilibria (gravimetry, potentiometry, conductivity measurements);
- Oxidation state and redox reactions (redox-titrations, galvanic elements);
- Metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration)
- Qualitative analysis (cation and anion separation, determination of cations and anions).

Latest online enrolment is 18.09.2023.
Information about the practical course will be given on the first day.
In the general chemistry practical course students are introduced to the work in chemistry laboratory. During the course they become familiar with common chemistry glassware and related equipment as well as learn basic experimental procedures, such as distillation, recrystallization, purification, digestion etc. Upon the measurements of pH, conductivity, and potential in the course of reactions, students establish the understanding of the chemical equilibrium concept.

Students work with various classes of inorganic compounds and types of chemical reactions, e.g. acid-base, redox, precipitation. They also obtain first experience with the synthesis of metal complexes as well as learn basics of qualitative analysis of an unknown substance.

**Literature**
Moodle Lernplattform

**Prerequisites / notice**
Compulsory: online enrolment latest one week after start of the semester

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.

**Competencies**

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529-0016-00L BCB III: Organic Chemistry

**Abstract**
Laboratory course in Organic Chemistry for students of "Biochemistry - Chemical Biology"

**Objective**
Introduction into basic techniques used in the organic laboratory. Understanding organic reactions through experiments.

**Content**
Part I: Basic operations such as the isolation, purification, and characterization of organic compounds: distillation, extraction, chromatography, crystallization, IR (UV/1H-NMR)-spectroscopy for the identification of the constitution of organic compounds.

Part II: Organic reactions: preparative chemistry. From simple, one-step to multi-step syntheses. The syntheses include classic Organic Chemistry as well as methods widely used in a Chemical Biology context.

**Lecture notes**
see https://bode.ethz.ch/education/bcb-iii/bcb-iii-lab-course.html

**Literature**

**Prerequisites / notice**
Basisprüfung + BCB I: General Chemistry

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.

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**Block Courses**
Registration for Block courses is mandatory. Please register under https://www.mybiportal.uzh.ch. Registration period: from DATUM

Please note the ETH admission criteria for the admission of ETH students to ETH block courses on the block course registration website under "allocation".

**Block Courses in the 1st Quarter of the Semester**

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<td>Understanding and Engineering Microbial Metabolism</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>J. Vorholt-Zambelli</td>
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Number of participants limited to 6. The enrolment is done by the D-BIOL study administration.

**Abstract**
The focus of this laboratory course is on current research topics related to metabolic engineering and the general understanding of metabolism, particularly in relation to one carbon metabolism. Projects will be carried out in small teams.

**Objective**
The course aims at introducing technologies to investigate bacterial metabolism and key principles of metabolic engineering. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular genetic, biochemical and analytical techniques including metabolomics. Results will be presented by students in scientific presentations. Another goal is to learn how to write a scientific report.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 244 of 2667
The course and will include topics such as pathway elucidation & engineering and related ongoing research projects in the lab. Experimental work applied during the course will comprise methods such as cloning work & transformation, growth determination, enzyme activity assays, liquid-chromatography mass-spectrometry and dynamic labeling experiments.

Experimental work applied during the course will comprise methods such as cloning work & transformation, growth determination, enzyme activity assays, liquid-chromatography mass-spectrometry and dynamic labeling experiments.

Lecture notes
None

Literature
Will be provided at the beginning of the course.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Problem-solving fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered

Personal Competencies
Adaptability and Flexibility fostered
Critical Thinking fostered

551-1421-00L The Mechanisms of Natural Transformation in Competent Gram-Negative Bacteria

Number of participants limited to 5.
The enrolment is done by the D-BIOL study administration.

Abstract
Students will carry out defined research projects related to the current research topics of the Hospenthal group. The topics will include protein expression of pilins and/or other competence proteins from Gram-negative bacteria, protein purification using affinity chromatography, crystallisation experiments and analysis of assembled pil by electron microscopy.

Objective
The course should enable students to understand concepts of protein expression, purification and the characterisation of biomolecular interactions. In addition, students will learn some basic principles of X-ray crystallography and electron microscopy.

Content
The students will be tutored in their experimental work by an experienced doctoral student. The course will also include a short lecture delivered by M. Hospenthal, providing the theoretical background for the experimental work. Throughout the course, students will receive exercises that further help to explain the theory of the practical work, as well as literature research tasks.

Participation in the following Hospenthal lab projects will be possible:
• Purification, biophysical characterisation and structure determination of pilins
• Purification, biophysical characterisation and structure determination of proteins and protein complexes involved in natural transformation.

Experimental work on this project involves:
• Cloning and mutagenesis
• Recombinant or endogenous protein production in E. coli or Legionella
• Protein purification by affinity chromatography (other chromatographic purification techniques will also be discussed)
• Protein crystallisation and crystal optimisation
• Visualisation of bacterial pil by electron microscopy (negative stain or cryo electron microscopy)
• DNA binding experiments
• Enzymatic activity measurements
• In silico structural analyses using PyMOL and Chimera

Literature
Any required reading of literature will be discussed at the beginning of the course.

Prerequisites / notice
There are no special requirements for this course.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered

Personal Competencies
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Block Courses in the 2nd Quarter of the Semester

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<td>W.-D. Hardt, B. Nguyen</td>
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The enrolment is done by the D-BIOL study administration.

Abstract
Research laboratory class in small groups. Research projects on current topics in cellular microbiology and bacterial pathogenesis are assigned to each student.

Objective
Introduction to a current topic in cellular microbiology, molecular genetics of a bacterial pathogen or its interaction with the host's microbiome. Experimental work in the research lab and introduction to the current lab techniques. This includes contributions to the analysis of animal experiment. You will work with the current research literature in bacterial pathogenesis and write a research protocol. Requirement for obtaining the credit points: oral presentation of the research project, a short written exam and evaluation of the research protocol.

Content
Research projects on the model pathogen Salmonella.

Lecture notes
none.

Literature
Literature will be selected with reference to the assigned research project.
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<td>Self-direction and Self-management</td>
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**551-0351-00L Membrane Biology**

**Number of participants limited to 12.**

The enrolment is done by the D-BIOL study administration.

**Abstract**
The course will introduce the students to the key concepts in membrane biology and will allow them to be involved in laboratory projects related to that broad field. The course will consist of lectures, literature discussions, and practical laboratory work in small groups. Results of the practical projects will be presented during the poster session at the end of the course.

**Objective**
The aim of the course is to expose the students to a wide range of modern research areas encompassed by the field of membrane biology.

**Content**
Students will be engaged in research projects aimed at understanding the biological membranes at the molecular, organellar and cellular levels. Students will design and perform experiments, evaluate experimental results, analyze the current scientific literature and understand the relevance of their work in the context of the current state of the membrane biology field.

**Lecture notes**
No script

**Literature**
The recommended literature, including reviews and primary research articles, will be provided during the course

**Prerequisites / notice**
The course will be taught in English. All general lectures will be held at ETH Hoenggerberg. Students will be divided into small groups to carry out experiments at ETH or at the Paul Scherrer Institute. Travel to the Paul Scherrer Institute will be by public transportation.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td></td>
<td>Self-direction and Self-management</td>
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**551-0359-00L Plant Biochemistry**

**Number of participants limited to 11.**

The enrolment is done by the D-BIOL study administration.

**Abstract**
In this block course, students actively participate in ongoing research projects in plant metabolism and plant cell biology, supervised by PhD students and postdoctoral fellows in small groups. The research background is discussed in Journal Clubs. At the end of the course, students present their projects and results in an interactive poster session.

**Objective**
Students are able to independently apply and record current molecular biology methods on plants, critically evaluate and communicate the results, understand the larger context of their research project and develop ideas for further experiments.

**Content**
Projects are newly designed each year and announced a few days before the course starts. Possible projects include the cell biology of starch granule formation (using fluorescence and electron microscopy and protein-protein interaction studies) or RNA metabolism in chloroplasts (using import assays and RNA detection).

**Lecture notes**
No script

**Literature**
Descriptions of the possible projects including individual reading suggestions will be handed out beforehand.
Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

551-1609-00L Single Molecule Biophysics Studies of the Microtubule Cytoskeleton

Number of participants limited to 5.
The enrolment is done by the D-BIOL study administration.

Abstract
This laboratory course has a focus on current research topics in our laboratory related to microtubule nucleation and dynamics and its investigation using in vitro reconstitutions and single molecule biophysics. Projects will be conducted in small groups.

Objective
The course aims to introduce technologies to investigate cytoskeletal processes and regulation using in vitro reconstitutions and single molecule biophysics methods. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular protein purification and biophysical techniques including single molecule fluorescence imaging using Total Internal Reflection Fluorescence Microscopy (TIRFM) and subsequent image analysis methods. Results will be presented by students in scientific presentations. Another goal is to learn how to write a scientific report.

Content
The course will include topics such as microtubule polymerization dynamics and related ongoing research projects in the lab. Experimental work applied during the course will comprise methods such as cloning work & transformation, protein purification, single molecule fluorescence imaging using Total Internal Reflection Fluorescence Microscopy (TIRFM), and single molecule image analysis.

Competencies

Subject-specific Competencies
- Concepts and Theories fostered
- Techniques and Technologies fostered

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving fostered
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

529-0044-00L Genetic Code Expansion for Studying Posttranslational Modifications

Enrolment limited to max 8 students. The enrolment is done by the D-BIOL study administration.

Abstract
In this block course we will prepare proteins bearing site-specifically installed post-translational modifications using genetic code expansion. The impact of the post-translational modifications on enzymatic activity and protein-protein interactions will be studied.

Objective
Students will learn basic techniques for genetic code expansion. They will learn how to synthesize non-canonical amino acids (ncAAs), manipulate plasmids through cloning techniques to introduce an amber codon at a user defined site in a gene of interest, express and purify recombinant proteins bearing site-specific ncAAs using state-of-the-art chromatographic techniques, characterize the target protein using mass spectrometry and analyze the properties of the target protein regarding enzymatic activity and protein-protein interactions using biophysical techniques.

After the course, participants should be able to apply the gained skills in future chemical and molecular biology lab courses and projects. Individual reports describing the experiments and obtained results must be prepared by the end of the course. At the end of the course, each team (consisting of two participants each) will present their results in an oral presentation.
Content
During this block course, the participants will study the impact of different post-translational modifications (PTMs) on protein function using genetic code expansion. The participants will work in teams of two, will first synthesize different ncAAs mimicking PTMs, such as acylated lysine derivatives (e.g., acetyllysine, butyryllysine etc.). These ncAAs will be incorporated into target proteins using orthogonal aminoacyl tRNA synthetase / tRNA pairs, which direct the site-specific incorporation in response to an in frame introduced amber stop codon (amber suppression). Therefore, the participants will introduce the amber stop codon at different positions in the gene of interest using standard molecular cloning techniques. After recombinant expression of the target protein, the participants will isolate the ncAA-bearing target proteins using different chromatography techniques using a FPLC system. After characterization of the PTM-bearing protein using mass spectrometry, the participants will study the impact of the PTM on enzymatic activity and protein-protein interactions using biophysical techniques.

Lecture notes
All the required theoretical and experimental informations can be found in the provided script. Details will be discussed in class. Relevant research papers will be recommended for reading during the seminars.

Prerequisites / notice
This laboratory block course is designed for 3 weeks, 3.5 days. Students should have basic practical knowledge in organic synthesis, molecular cloning, protein expression and purification (participants must have attended the practical course BCB-IV prior to this block course). The maximum number of participants is currently limited to 8. Interested applicants may contact Dr. M. Fottner for further information. Commitment for attendance of entire course is necessary. The course cannot be interrupted by individual absences once started.

Block Courses in the 3rd Quarter of the Semester

<table>
<thead>
<tr>
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<th>Lecturers</th>
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<td>529-0739-01L</td>
<td>Biological Chemistry B: New Enzymes from Directed Evolution Experiments</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>P. A. Kast, M. Levasseur</td>
</tr>
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</table>

The enrolment is done by the D-BIOL study administration.

Abstract
During the block course, the participants will carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The class will have its very dense program consists of the practical course itself and an integrated series of seminar/lecture sessions.

Objective
All technologies used for the experiments will be explained to the students in theory and in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

Content
The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. By working in parallel, teams of 2 participants each will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes’ kinetic parameters, their molecular mass, and the integrity of the protein structure. The results obtained from the individual evolution experiments will be compared and discussed at the end of the class in a final seminar. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalysts.

Lecture notes
A script will be distributed to the participants on the first day of the course.

Literature


Further literature will be indicated in the distributed script.

Prerequisites / notice
This laboratory block course will involve experiments that require a tight schedule and, particularly in the second half, very long (1) working days. The maximum number of participants for the laboratory class is limited, but surplus applicants may contact P. Kast directly to have their names added to a waiting list. A valid registration is considered a commitment for attendance of the entire course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast. For more information see http://www.kast.ethz.ch/teaching.html, from where you can also download a flyer.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered

Personal Competencies
Adaptability and Flexibility assessed
Self-presentation and Social Influence fostered
Critical Thinking fostered
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed

Bioactive Natural Products from Bacteria
Number of participants limited to 8. The enrolment is done by the D-BIOL study administration.

Abstract
Lab course. In small groups projects of relevance to current research questions in the field of bacterial natural product biosynthesis are addressed.

Objective
Introduction to relevant subjects of the secondary metabolism of bacteria. Training in practical work in a research laboratory. Scientific writing in form of a research report.

Content
Research project on bacteria that produce bioactive natural products (e.g., Streptomycetes, Cyanobacteria, uncultivated bacteria). The techniques used will depend on the project, e.g. PCR, cloning, natural product analysis, precursor feeding studies, enzyme expression and analysis.
### Microbial Community Genomics

**Number of participants limited to 10.**

**Prerequisites:** Participants should bring their own laptop computer. Basic knowledge in [R], Python and/or UNIX is required.

**Abstract**

We provide training in the use of computational methods to address molecular, genetic, ecological and/or evolutionary questions by analyzing DNA sequencing data from microbial communities. The course includes lectures, tutorials, and the development of a research project at the intersection between microbiology and bioinformatics.

**Objective**

Students will learn concepts and methods for analyzing complex 'omics' datasets and applying them in individual projects. To facilitate learning, the course includes lectures on functional genomics, metagenomics and microbiology, along with practical sessions on scientific programming to analyze and visualize biological data. Additionally, students will learn how to plan, execute, report on, and present a scientific project.

**Prerequisites / notice**

Participants should bring their own laptop computer. Basic knowledge in [R], Python and/or UNIX is required.

#### Competencies

<table>
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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</table>

#### Literature

- Große Auswahl an Fachbüchern und Forschungsartikeln
- Intermolecular and Surface Forces - Elsevier

### Polymer Physics Methods for Unstructured Biomolecules

**Enrollment limited to 12 students. Enrollment is done by the D-BIOL study administration.**

**Abstract**

Establishing a link between known phenomena, concepts and spectroscopic techniques in polymer physics on the one hand and the study of unstructured biological macromolecules on the other. Attention is paid to the relationship between molecular interactions in biopolymers and their tendency to form molecular condensates, such as membraneless organelles.

**Objective**

Expansion of competences for the experimental and analytical treatment and structural characterization of partially and completely unstructured biomacromolecules as well as their interactions and self-organization.

**Content**

Part I: Molecular interactions, concepts of polymer physics, spectroscopic methods; Part II: Polymer types in biology - proteins, DNA/RNA, polysaccharides, lipids; Part III: Molecular modeling and determination of conformational ensembles.

**Lecture notes**

Script for part I of the course in HS2024; slides for all three parts

**Literature**

- Greek auswahl an Fachbüchern und Forschungsartikeln
- Polymer Physics - Oxford Press 2003

#### Competencies

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#### Literature

- Große Auswahl an Fachbüchern und Forschungsartikeln
- Intermolecular and Surface Forces - Elsevier

### Block Courses in the 4th Quarter of the Semester

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<tr>
<td>529-0053-00L</td>
<td>Polymer Physics Methods for Unstructured Biomolecules</td>
<td>W</td>
<td>6 credits</td>
<td>7G</td>
<td>M. Yulikov, L. Galazzo, G. Jeschke</td>
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<tr>
<td>529-0009-00L</td>
<td>Characterization of the Aggregation Landscape of Peptide Amyloids and their Chemical Templating</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>R. Riek, J. Greenwald</td>
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</tbody>
</table>

#### Literature

- Große Auswahl an Fachbüchern und Forschungsartikeln
- Intermolecular and Surface Forces - Elsevier

#### Prerequisites

- Participants should bring their own laptop computer. Basic knowledge in [R], Python and/or UNIX is required.

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**Data:** 02.07.2024 12:39

**Autumn Semester 2024**

**Page 249 of 2667**
Introduction to the diversity of current RNA-research at all levels from structural biology to systems biology using mainly model systems like S. cerevisiae (yeast), mammalian cells.

The students will gain an overview about the diversity of current RNA-research. They will learn to design experiments and use techniques necessary to analyze different aspects of RNA biology. Through lectures and literature seminars, they will learn about the burning questions of RNA research and discuss approaches to address these questions experimentally. In practical lab projects the students will work in one of the participating laboratories. Finally, they will learn how to present and discuss their data in an appropriate manner. Student assessment is a graded semester performance based on individual performance in the laboratory, the written exam and the poster presentation.

Documentation and recommended literature will be provided at the beginning and during the course.

The course will be taught in English.

Subject-specific Competencies

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<th>Concepts and Theories</th>
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<td>Cooperation and Teamwork</td>
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<td>Self-direction and Self-management</td>
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551-1417-00L In Vivo Cryo-EM Analysis of Dynein Motor Proteins

Abstract

Motor proteins convert chemical energy into mechanical motion. In this block course, we study dynein motor proteins in cilia. Dynein causes conformational change upon ATP hydrolysis and finally generate ciliary bending motion. Participants will analyze cryo-EM data of cilia and visualize in vivo 3D structure of dynein to learn how motor proteins function in the cell.

Objective

The goal of this course is to be familiar with structural biology techniques of cryo-electron tomography and single particle cryo-EM studies on motor proteins. The main focus is 3D image analysis of cryo-EM datasets acquired by highest-end microscopes. Participants will learn structure-function relationship at various scales: how the conformational change of motor proteins causes mechanical force and generates cellular motility.

Content

Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. Their function is essential for intracellular transport, muscle contraction and other cellular motility as well as cell division. Motor proteins have been major targets of biophysical studies. There exist questions from atomic to tissue levels – how ATP hydrolysis causes conformational change of motor proteins; how their motion is regulated by calcium, phosphorylation and other factors; how motions of multiple motor proteins are coordinated to generate cellular motility. Structural biology has been playing central roles to answer these questions. X-ray crystallography and single particle cryo-EM address structural analysis at atomic resolution and try to reveal molecular mechanism of conformational change. Cryo-electron tomography analyze localization and 3D structure of motor proteins in the cell to explain how motions of molecular motors happen in the context of cellular environment and are integrated into cellular motion.

In this course, we study dyneins in cilia. Cilia are force-generating organelles, made by nine microtubules and thousands of dyneins. Dynein hydrolyzes ATP and undergoes conformational change, generating linear motion with respect to the microtubule. As a whole system, cilia integrate motions of these dyneins and orchestrate beating motion. To explain ciliary motion at molecular level, we need to know dynein conformational change in the cellular context. Cryo-electron tomography is recently developed technique to study molecular structures in vivo and therefore a suitable method to study dynein in cilia. Recently spatial resolution of these cryo-EM techniques was dramatically improved, driven by development of new types of detectors and electron optics. The participants of this course will learn a program to analyze cryo-electron tomography and single particle cryo-EM data, acquired by highest-end electron microscopes and detectors in ETH and other places, and reconstruct 3D structure (tomogram) of cilia from various organisms (from green algae to human). They will further learn a program to study molecular structures from these tomograms (called subtomogram averaging) and apply it to reconstruct high-resolution 3D structure of dyneins, microtubules and regulatory proteins. This practical course is therefore mainly computational, but we will also provide students a chance to prepare data from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH.

Abstract

An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Objective

Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

Content

An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Number of participants limited to 5.

The enrolment is done by the D-BIOL study administration.

The course notes.

No set textbooks. Literature will be indicated or provided by the supervising tutors.

Autumn Semester 2024
Prerequisites / notice
Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.

Competencies
Subject-specific Competencies  Concepts and Theories  assessed
Techniques and Technologies  assessed
Method-specific Competencies  Analytical Competencies  assessed
Decision-making  fostered
Media and Digital Technologies  fostered
Problem-solving  assessed
Project Management  fostered

Social Competencies
Communication  fostered
Cooperation and Teamwork  fostered
Self-presentation and Social Influence  fostered
Sensitivity to Diversity  fostered

Personal Competencies
Adaptability and Flexibility  fostered
Creative Thinking  fostered
Critical Thinking  fostered
Integrity and Work Ethics  fostered
Self-awareness and Self-reflection  fostered
Self-direction and Self-management  fostered

Block Courses in the 2nd Half of the Semester

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<td>C. Thilgen</td>
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Abstract
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Objective
Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

Content
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Lecture notes
No course notes.

Literature
No set textbooks. Literature will be indicated or provided by the supervising tutors.

Prerequisites / notice
Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.

Competencies
Subject-specific Competencies  Concepts and Theories  assessed
Techniques and Technologies  assessed
Method-specific Competencies  Analytical Competencies  assessed
Decision-making  fostered
Media and Digital Technologies  fostered
Problem-solving  assessed
Project Management  fostered

Social Competencies
Communication  fostered
Cooperation and Teamwork  fostered
Self-presentation and Social Influence  fostered
Sensitivity to Diversity  fostered

Personal Competencies
Adaptability and Flexibility  fostered
Creative Thinking  fostered
Critical Thinking  fostered
Integrity and Work Ethics  fostered
Self-awareness and Self-reflection  fostered
Self-direction and Self-management  fostered

Electives

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<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>535-0230-00L</td>
<td>Medicinal Chemistry I</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>J. Hall</td>
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Abstract
The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

Objective
Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

Content
Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions.

Lecture notes
Will be provided in parts before each individual lecture.

Literature
### 551-0313-00L Microbiology (Part I)

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<tr>
<th>Competencies</th>
<th>Methods</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>fostered</td>
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<tr>
<td>Social Competencies</td>
<td>Leadership and Responsibility</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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</table>

#### Abstract
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

#### Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

#### Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

#### Literature
Updated handouts will be provided during the class.

#### Prerequisites / Notice
English

The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

### 529-0041-00L Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

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<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Social Competencies</td>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Project Management</td>
<td>fostered</td>
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</table>

#### Abstract
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation.

#### Objective
Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

#### Content
Use of modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging.

#### Literature
Updated handouts will be provided during the class.

#### Prerequisites / Notice
Lecture notes will be made available online.

### 529-0132-00L Inorganic Chemistry III: Organometallic Chemistry and Homogeneous Catalysis

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<th>Competencies</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>fostered</td>
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<tr>
<td>Social Competencies</td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Project Management</td>
<td>fostered</td>
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</table>

#### Abstract
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions, Catalytic hydrogenation, carboxylation, C-C bond-forming and related reactions.

#### Objective
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

#### Content
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carboxylation, C-C bond-forming and related reactions.

### 551-0319-00L Cellular Biochemistry (Part I)

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Methods</th>
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</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<tr>
<td>Social Competencies</td>
<td>Leadership and Responsibility</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Self-awareness and Self-reflection</td>
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</table>

#### Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

#### Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

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### Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.
Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

### Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

### Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

### Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

### Competencies
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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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### 551-1299-00L Bioinformatics

**Abstract**
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

**Objective**
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

**Prerequisites / notice**
Course participants have already acquired basic programming skills in UNIX, Python and R.

**Competencies**
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<th>Subject-specific Competencies</th>
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<td>Techniques and Technologies</td>
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</table>

### 529-0231-00L Organic Chemistry III: Introduction to Asymmetric Synthesis

**Abstract**
Methods of Asymmetric Synthesis

**Objective**
Understanding the basic principles of diastereoselective synthesis

**Content**
Conformational analysis: acyclic and cyclic systems; Diastereoselective sigmatropic rearrangements; Diastereoselective Carbonyl addition reactions: Cram- and Felkin-Anh models, carbonyl Lewis acid interactions, chelate controlled reactions; chemistry of enolates, selective formation; asymmetric enolate alkylation; aldol reactions, allyl- and crotyl-metal chemistry; cyclisations, Baldwin rules; Diastereoselective olefin functionalization: hydroboration, dihydroxylation, epoxidation.

**Literature**

**Evans’ Problems in Organic Chemistry App**

**Competencies**
<table>
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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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### Science in Perspective

**Science in Perspective**
see Science in Perspective: Type A: Enhancement of Reflection Capability

**Recommended Science in Perspective (Type B) for D-**

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## Language Courses

### Biochemistry – Chemical Biology Bachelor - Key for Type

<table>
<thead>
<tr>
<th></th>
<th>eligible for credits</th>
<th>suitable for doctorate</th>
<th>compulsory</th>
<th>eligible for credits and recommended</th>
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<td>E-</td>
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<td>O</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>W+</td>
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### Key for Hours

<table>
<thead>
<tr>
<th></th>
<th>lecture</th>
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<th>exercise</th>
<th>seminar</th>
<th>colloquium</th>
<th>practical/laboratory course</th>
<th>independent project</th>
<th>diploma thesis</th>
<th>revision course / private study</th>
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### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
Core Subjects and Compensatory Courses

Core Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0733-02L</td>
<td>Chemical Biology and Synthetic Biochemistry</td>
<td>O</td>
<td>6</td>
<td>3G</td>
<td>K. Lang, M. Fottner</td>
</tr>
<tr>
<td>Abstract</td>
<td>Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.</td>
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<tr>
<td>Objective</td>
<td>After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context. B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vitro - in vivo. C) Critically analyze and assess current chemical biology articles. D) Question the approaches learned and apply them to new biological problems.</td>
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<tr>
<td>Content</td>
<td>Advanced genetic code expansion methods (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing) directed evolution and protein engineering.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts to the lecture will be provided through moodle.</td>
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<tr>
<td>Literature</td>
<td>Citations from the original literature relevant to the individual lectures will be assigned during the lectures.</td>
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<tr>
<td>Prerequisites</td>
<td>Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.</td>
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<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
<th>Project Management</th>
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<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
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<td>fostered</td>
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<td>Ad hoc and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Social Competencies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Personal Competencies</td>
<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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| 529-0240-00L | Chemical Biology - Peptides | O      | 6    | 3G    | H. Wennemers |
| Abstract     | An advanced course on the synthesis, properties and function of peptides in chemistry and biology. |
| Objective    | Knowledge of the synthesis, properties and function of peptides in chemistry and biology. |
| Content      | Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis. |
| Lecture notes| Citations from the original literature relevant to the individual lectures will be assigned weekly. |

| 529-0241-10L | Selectivity in Organic Synthesis | O      | 6    | 3G    | J. W. Bode |
| Abstract     | Fundamentals of selective organic reactions, including current and historical examples of enantioselectivity, regioselectivity, chemoselectivity. Further aspects include recent developments in catalysis, strategies and tools for selective organic synthesis. |
| Objective    | Understanding and explaining the origin of selectivity in organic synthesis and the application of selective organic reactions to the construction of complex organic and biological molecules. |
| Content      | Fundamental concepts and recent advances for the selective synthesis of complex organic molecules, including natural products, pharmaceuticals, and biological molecules. Key concepts include the development of enantioselective and regioselective catalysts, the identification of new reaction mechanisms and pathways, and technological advances for facilitating the synthesis of organic molecules. Analysis of key primarily literature including identification of trends, key precendents, and emerging topics will be emphasized. |
| Lecture notes| will be provided in class and online |
The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific properties required for their applications. This includes understanding the principles of polymerization processes, kinetic aspects, and the importance of reaction mechanisms. Students will also learn about writing an original research proposal and the regulatory aspects of these processes.

**Literature**

- **Biochemical and Polymer Reaction Engineering**: R.W. Blanch, D.S. Clark, Biochemical Engineering, CRC Press, 1995
- **Surfactants and Colloid Stability**: H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

**Additional References**

- **Kinetics and control of emulsion polymerization**: H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995
- **Additional handout of slides will be provided during the lectures.**

**Prerequisites**


**Compensatory Courses**

Compensatory courses can be used to compensate for core subjects that have been failed twice. The assignment of the corresponding course units to the regulatory category "core subjects and compensatory courses" in the transcript of records is only made upon application by the student to the study administration office of the degree programme.
Abstract
In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

Objective
Students know and understand:
- basic mechanisms and regulation of the immune response
- the pathogenic mechanisms of the most important immune-mediated disorders
- the concepts of vaccination and cancer immunotherapy
- the most frequently used expression systems for the production of therapeutic proteins
- the use of protein engineering tools for modifying different features of therapeutic proteins
- the mechanism of action of selected therapeutic proteins and their application
- basic concepts in the GMP production of therapeutic proteins

Content
The course consists of two parts:

In the first part, students will complete their training in Pharmaceutical Immunology. This part particularly focuses on the pathogenic mechanisms of immune-mediated diseases, vaccination and cancer immunotherapy. Deepened knowledge of immunology will be relevant for understanding the mechanism of action of many therapeutic proteins, as well as for understanding one major concern related to the use of protein-based drugs, namely, immunogenicity.

The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

Lecture notes
Handouts to the lectures will be available for downloading under http://www.pharma.ethz.ch/scripts/index

Prerequisites / notice
Prerequisites: Either 535-0830-00L Pharmaceutical Immunology I or 551-0317-00L Immunology I

Competencies
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<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Problem-solving</td>
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535-0230-00L Medicinal Chemistry I

Objective
Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

Content
Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions

Lecture notes
Will be provided in parts before each individual lecture.

Literature
- J. Piel, M. Pihlofer, A. Vagstad

Prerequisites / notice
Attendance of Medicinal Chemistry II in the spring semester.

551-0313-00L Microbiology (Part I)

Objective
Advanced course on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
This concept will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes
Updated handouts will be provided during the class.

Literature
Current literature references will be provided during the lectures.

Prerequisites / notice
English

529-0041-00L Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

Objective
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Content
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Abstract
Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging.

Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Lecture notes
Lecture notes will be made available online.

Literature
Information about relevant literature will be available in the lectures.

Prerequisites / notice
Exercises are an integral part of the lecture. Prerequisites:
- 529-0051-00 "Analytische Chemie I (3. Semester)"
- 529-0058-00 "Analytische Chemie II (4. Semester)" (or equivalent)
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

### Abstract

Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

### Competencies

**Subject-specific Competencies**

- Concepts and Theories: fostered
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### Prerequisites / notice

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.
Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics.

**Content**

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**

Scripts and additional material will be provided during the semester.

**Competencies**

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Social Competencies

- Communication
- Self-presentation and Social Influence

Personal Competencies

- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

---

**551-0317-00L Immunology I**

**Abstract**

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**

- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
  - B cells and antibodies
  - Generation of diversity
  - Antigen presentation and Major Histoincompatibility (MHC) antigens
  - Thymus and T cell selection
  - Autoimmunity
  - Cytotoxic T cells and NK cells
  - Th1 and Th2 cells, regulatory T cells
  - Allergies
  - Hypersensitivities
  - Vaccines, immune-therapeutic interventions

**Lecture notes**

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

**Literature**

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Prerequisites / notice**

For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

**Competencies**

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

---

**551-0127-00L Fundamentals of Biology III: Multicellularity**

**Abstract**

The lecture conveys the fundamental concepts underlying multicellularity with an emphasis on the molecular basis of multicellular biological systems and their functional integration into coherent wholes. The structural and functional specialization in multicellular organisms will be discussed by highlighting common and specific functions in fungi, plants, and animals (including humans).

**Objective**

1. Students can describe advantages and challenges associated with being multicellular and outline independent solutions that organisms have developed to cope with the challenges of complex multicellularity.
2. Students can explain how the internal and external structures of fungi, plants and animals function to support survival, growth, behavior, and reproduction.
3. Students can explain the basic pathways and mechanisms of cellular communication regulating cellular behavior (cell adhesion, metabolism, proliferation, reproduction, development).
4. Students can describe how a single cell develops from one cell into many, each with different specialized functions.
Content

The lecture introduces the structural and functional specialization in fungi, plants and animals, including humans. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi, plants, animals and humans have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, human anatomy and physiology, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development.

Literature

Campbell “Biology”, 11th Edition

Prerequisites / notice

Some lecture are held in English.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed

Social Competencies
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking assessed

Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Abstract

The course will introduce students to a selected set of laboratory techniques that are foundational to modern biological research.

Objective

For each of the techniques covered in the course, the students will be able to explain:

a) the physical, chemical and biological principles underlying the technique,

b) the requirements for the sample,

c) the type of raw data collected by the technique,

d) the assumptions and auxiliary information used in the interpretation of the data and

e) how these data can be used to answer a given biological question.

By the end of the course the students will be able to select the appropriate experimental technique to answer a given biological problem and will be able to discuss the advantages and limitations of individual techniques as well as how different techniques can be combined to gain a more complete understanding of a given biological questions.

Content

The course will be based on a combination of lectures, self-study elements and exercises.

The focus will be on the following experimental techniques:

- DNA sequencing
- chromatography
- mass-spectrometry
- UV/Vis and fluorescence spectrometry
- light microscopy
- electron microscopy
- X-ray crystallography
- NMR spectroscopy

Lecture notes

The course is supported by a Moodle page that gives access to all supporting materials necessary for the course.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered

Abstract

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective

Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature

See: www.csms.ethz.ch/education/CSBMS

Prerequisites / notice

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS
Subject-specific Competencies

fostered

Cell Biophysics

fostered

Media and Digital Technologies

assessed

Objectives

The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific

analytical models. Experimental results from the literature.

The objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles

from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from

the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs

free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action

potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive

a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding

experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

529-0043-01L

Analytical Strategy

W 6 credits

3G R. Zenobi, S. Giannoukos, D. Günther

Abstract

Problem-oriented development of analytical strategies and solutions.

Objective

Ability to create solutions for particular analytical problems.

Content

Individual development of strategies for the optimal application of chemical, biochemical, and physico-chemical methods in analytical

chemistry solving predefined problems. Experts from industry and administration present particular problems in their field of activity.

Lecture notes / notice

Copies of problem sets and solutions will be distributed free of charge

Prerequisites

529-0051-00 "Analytical Chemistry I (3. Semester)"

529-0058-00 "Analytical Chemistry II (4. Semester)"

(or equivalent)

529-0615-01L

Biochemical and Polymer Reaction Engineering

W 6 credits

3G P. Arosio, P. Fleckenstein

Abstract

Polymerization reactions and processes. Homogeneous and heterogeneous (emulsion) kinetics of free radical polymerization. Post

treatment of polymer colloids. Bioprocesses for the production of molecules and therapeutic proteins. Kinetics and design of aggregation

processes of macromolecules and proteins.

Objective

The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific

product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-
treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

Content

We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In

particular, the following topics are discussed: Overview on the different polymerization processes. Kinetics of free-radical polymerization

and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution.

Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in

conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical

characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and

downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in

biology and in biotechnology as functional materials.

Lecture notes

Additional handout of slides will be provided during the lectures.

Literature


H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

527-0939-00L

Cell Biophysics

W 6 credits

4G T. Zambelli

Abstract

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is

derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding

experimental data in the literature.

Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the

question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles

from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from

the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs

free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action

potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive

a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding

experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.
Content
• Basics of theory of probability
• Boltzmann's law
• Entropy maximization and Gibbs free energy minimization
• Ligand-receptor: two-state systems and the MWC model
• Random walks, diffusion, crowding
• Electrostatics for salty solutions
• Elasticity: fibers and membranes
• Molecular motors
• Action potential: Hodgkin-Huxley model
• Photosynthesis and vision
• Gene regulation
• Development: Turing patterns

Theory and corresponding exercises are merged together during the classes.

Lecture notes
No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o'clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle!!!

Literature

As further deepening:

Prerequisites / notice
Participants need a good command of
• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity assessed
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

529-0231-00L Organic Chemistry III: Introduction to Asymmetric Synthesis 4 credits 3G E. M. Carreira

Abstract
Methods of Asymmetric Synthesis

Objective
Understanding of the basic principles of diastereoselective synthesis

Content
Conformational analysis: acyclic and cyclic systems; Diastereoselective sigmatropic rearrangements; Diastereoselective Carbonyl addition reactions: Cram- and Felkin-Anh models, carbonyl Lewis acid interactions, chelate controlled reactions; chemistry of enolates, selective formation; asymmetric enolate alkylation; aldol reactions, allyl- and crotyl-metal chemistry; cyclisations, Baldwin rules; Diastereoselective olefin functionalization: hydroboration, dihydroxylation, epoxidation.

Literature
Evans' Problems in Organic Chemistry App
Concepts of the planning of organic synthesis (strategy and tactics), retrosynthetic analysis. Structure-reactivity relation in the context of  

to yield materials with enhanced polymeric characteristics.

1) The students will be able to recognize different polymer types and associate them with their chemical structure and properties (i.e. rubber elasticity, glass transition temperature, etc.)
2) The students will become familiar with various synthetic methods to produce polymers of different architectures and topologies
3) The students will be exposed to different characterization methods (e.g. size exclusion chromatography, mass-spectrometry, nuclear magnetic resonance) that are necessary to confirm the successful synthesis and structure of a polymer
4) The students will understand the mechanism of selected polymerization methodologies
5) The students will be introduced to state-of-the-art polymer synthesis and recent literature examples will be critically discussed

Lecture slides with references to further literature will be available on Moodle

L. Mandelkern, “An Introduction to Macromolecules”
J. M. G. Cowie “Polymers: Chemistry and Physics of Modern Materials”
publications mentioned on the slides

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.


Handout during the course.

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Analytical Competencies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

551-1407-00L RNA Biology Lecture Series I: Transcription & Processing & Translation

Objective
This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

Prerequisites / notice
Basic knowledge of cell and molecular biology.

529-0132-00L Inorganic Chemistry III: Organometallic Chemistry and Homogeneous Catalysis

Objective
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

Prerequisites / notice
Basic knowledge of cell and molecular biology.

551-1409-00L RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

Objective
This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

Prerequisites / notice
Basic knowledge of cell and molecular biology.

529-0243-01L Transition Metal Catalysis: From Mechanisms to Applications

Objective
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint.

Prerequisites / notice
Required level: Courses in organic and physical chemistry (kinetics in particular) of the first and second year as well as ACI and III

Competencies
- Subject-specific Competencies
- Method-specific Competencies
- Personal Competencies

Communication
- Assessed

Objective
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint. Synthetic applications of these reactions. Introduction and application of tools for the elucidation of mechanisms. Selected examples of topics include: C-H activation, C-O activation, C-C activation, reductively active ligands, main group redox catalysis, bimetallic catalysis.

Prerequisites / notice

Data: 02.07.2024 12:39
Autumn Semester 2024
Page 264 of 2667
Semester Theses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-0260-00L</td>
<td>Research Project I</td>
<td>O</td>
<td>16</td>
<td>34A</td>
<td>Lecturers</td>
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| 529-0265-00L | Research Project II    | O    | 16    | 34A   | Lecturers |
| Abstract     | In a research project  |      |       |       |           |
| Objective    | Students are           |      |       |       |           |
| Content      | accustomed to          |      |       |       |           |
|              | scientific work and    |      |       |       |           |
|              | they get to know one  |      |       |       |           |
|              | specific research field.|     |       |       |           |

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Master's Thesis

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<td>529-0080-00L</td>
<td>Master's Thesis</td>
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<td>69D</td>
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</table>

Duration of the Master's Thesis 26 weeks.

Objective

In the Master's Thesis students prove their ability to independent, structured and scientific working. The Master's thesis is usually carried out in a core or optional subject area as chosen by the student.

Biochemistry - Chemical Biology Master - Key for Type

<table>
<thead>
<tr>
<th>W</th>
<th>Recommended for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<th>Key for Hours</th>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Biology (General Courses)

#### Complementary Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>376-1791-00L</td>
<td>Introductory Course in Neuroscience I (University of Zurich)</td>
<td>Z Dr</td>
<td>2</td>
<td>2V</td>
<td>W. Knecht, University lecturers</td>
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<td><em>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</em></td>
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<td><em>UZH Module Code: SPV0Y005</em></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.</td>
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<tr>
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<td><strong>Objective</strong></td>
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<td>The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.</td>
</tr>
</tbody>
</table>
|              | **Content**                                                          |      |      |       | 1) Human Neuroanatomy I&II  
2) Comparative Neuroanatomy  
3) Building a central nervous system I,II  
4) Synapses I,II  
5) Glia and more  
6) Excitability  
7) Circuits underlying Emotion  
8) Visual System  
9) Auditory & Vestibular System  
10) Somatosensory and Motor Systems  
11) Learning in artificial and biological neural networks |
|              | **Prerequisites / notice**                                            |      |      |       | For doctoral students of the Neuroscience Center Zurich (ZNZ). |
| 151-0927-00L | Rate-Controlled Separations in Fine Chemistry                        | Z Dr | 6    | 3V+1U | M. Mazzotti, V. Becattini, N. Casas, F. Heier  |
|              | **Abstract**                                                          |      |      |       | The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology. |
|              | **Objective**                                                         |      |      |       | The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology. |
|              | **Content**                                                          |      |      |       | The class covers separation techniques that are central in the purification and downstream processing of chemicals and biopharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation. |
|              | **Lecture notes**                                                    |      |      |       | Handouts during the class                      |
|              | **Literature**                                                       |      |      |       | Recommendations for text books will be covered in the class |
|              | **Prerequisites / notice**                                            |      |      |       | Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00) |
|              | **Competencies**                                                     |      |      |       | Subject-specific Competencies:  
Concepts and Theories: assessed  
Techniques and Technologies: assessed  
Method-specific Competencies:  
Analytical Competencies: assessed  
Decision-making: fostered  
Media and Digital Technologies: fostered  
Problem-solving: assessed  
Project Management: fostered  
Social Competencies:  
Communication: assessed  
Cooperation and Teamwork: fostered  
Customer Orientation: fostered  
Leadership and Responsibility: fostered  
Self-presentation and Social Influence: fostered  
Sensitivity to Diversity: fostered  
Negotiation: fostered  
Personal Competencies:  
Adaptability and Flexibility: fostered  
Creative Thinking: fostered  
Critical Thinking: assessed  
Integrity and Work Ethics: fostered  
Self-awareness and Self-reflection: fostered  
Self-direction and Self-management: fostered  |
| 401-0649-00L | Applied Statistical Regression                                         | Z Dr | 5    | 2V+1U | M. Dettling                                    |
|              | **Abstract**                                                          |      |      |       | This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis. |
|              | **Objective**                                                         |      |      |       | The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling. |
|              | **Content**                                                          |      |      |       | The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicolinearity problems and model interpretation, as well as general modeling strategies. The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data. |
|              | **Lecture notes**                                                    |      |      |       | A script will be available.                    |

**Data:** 02.07.2024 12:39  **Autumn Semester 2024**  **Page 266 of 2667**
Communication
Subject-specific Competencies
ZüKoSt: Seminar on Applied Statistics

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

Literature
- Faraway (2005): Linear Models with R
- Faraway (2006): Extending the Linear Model with R
- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
- Montgomery et al. (2006): Introduction to Linear Regression Analysis

Additional information is given during the lecture.

Prerequisites / notice
The lecture requires an active participation of the students. All students will participate in individual or group work focusing on specific subject of the lecture. Students will have ample time for preparation during lecture time.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

401-5640-00L ZüKoSt: Seminar on Applied Statistics Z Dr 0 credits 1K M. Kalisch, F. Balabdaoui, A. Bandeira, Y. Chen, R. Furrer, T. Hothorn, L. Meier,
Presentations will be made available after the seminars. Students gain competences in presenting their work orally, leading discussions about current topics in ecology and evolution, interacting and assessing.

Analytical Competencies

Concepts and Theories

Techniques and Technologies

Decision-making

Problem-solving

Creative Thinking

Critical Thinking

Interaction seminar. Student-led presentations, guests and discussions on current themes in ecology, evolution and population biology.

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

Requirements: Knowledge of the basic concepts of statistics is desirable.

Method-specific Competencies

Subject-specific Competencies

Creative Thinking

Critical Thinking

Zürich Ecology and Evolution Interaction Seminar

The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

Lecture notes

Prerequisites / notice

You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

Zambelli

M. Künzler, J. Piel, J. Vorholt-Zambelli

N. Meinshausen, J. Peters,

F. Sigrist, C. Strobl, J. Ziegel

Abstract

Objective

Content

Prerequisites / notice

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Decision-making

Problem-solving

Project Management

Communication

Leadership and Responsibility

Self-presentation and Social Influence

Critical Thinking

Self-awareness and Self-reflection

Lecture notes

Prerequisites / notice

For information, location and details: https://pe.ethz.ch/education/zis.html

Competencies

Method-specific Competencies

Social Competencies

Personal Competencies

Current Immunological Research in Zurich

This monthly meeting is a platform for Zurich-based immunology research groups to present and discuss their ongoing research projects. At each meeting three PhD students or Postdocs from the participating research groups present an ongoing research project in a 30 min seminar followed by a plenary discussion.

551-1109-00L

Seminars in Microbiology

Z Dr 0 credits 2K

S. Sunagawa, W.-D. Hardt, M. Künzler, J. Piel, J. Vorholt-Zambelli

Abstract

Objective

Content

Prerequisites / notice

Competencies

Concepts and Theories

Techniques and Technologies

Decision-making

Problem-solving

Creative Thinking

Critical Thinking

Statistical Consulting

The Statistical Consulting service is open for all members of ETH, including students, and partly also to other persons.

Advice for analyzing data by statistical methods.

Students and researchers can get advice for analyzing scientific data, often for a thesis.

We highly recommend to contact the consulting service when planning a project, not only towards the end of analyzing the resulting data!

This is not a course, but a service. There are no exams nor credits.

Contact: beratung@stat.math.ethz.ch . Tel. 044 632 2223. See also http://stat.ethz.ch/consulting

Requirements: Knowledge of the basic concepts of statistics is desirable.

551-0512-00L

Current Topics in Molecular and Cellular Neurobiology

Z Dr 2 credits 1S

U. Suter

Abstract

Objective

Content

Lecture notes

Prerequisites / notice

Does not take place this semester.

Current seminars will be announced a week in advance of the presentation.

You are expected to attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

Zurich Ecology and Evolution Interaction Seminar

Interaction seminar. Student-led presentations, guests and discussions on current themes in ecology, evolution and population biology.

Students gain competences in presenting their work orally, leading discussions about current topics in ecology and evolution, interacting with colleagues from various subdisciplines, and engaging in critical dialogue about ongoing research projects.

Scientific presentations by doctoral students about ongoing research projects; guest presentations by established researchers, interactive discussions about current research in ecology, evolution and population biology.

None

None

For information, location and details: https://pe.ethz.ch/education/zis.html

501-0620-00L

Statistical Consulting

Z Dr 0 credits 0.1K

M. Kalisch, L. Meier

Abstract

Objective

Content

Prerequisites / notice

Contact: beratung@stat.math.ethz.ch . Tel. 044 632 2223. See also http://stat.ethz.ch/consulting

Requirements: Knowledge of the basic concepts of statistics is desirable.

Statistical Consulting

Advising on statistical methods and their applications.

Advice for analyzing data by statistical methods.

Students and researchers can get advice for analyzing scientific data, often for a thesis.

We highly recommend to contact the consulting service when planning a project, not only towards the end of analyzing the resulting data!

This is not a course, but a service. There are no exams nor credits.

Contact: beratung@stat.math.ethz.ch . Tel. 044 632 2223. See also http://stat.ethz.ch/consulting

Requirements: Knowledge of the basic concepts of statistics is desirable.

701-1400-00L

Zurich Ecology and Evolution Interaction Seminar

Z 1 credit 2S

A. Hall

Abstract

Objective

Content

Lecture notes

Literature

Prerequisites / notice

None

None

For information, location and details: https://pe.ethz.ch/education/zis.html

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Decision-making

Problem-solving

Creative Thinking

Critical Thinking

Self-awareness and Self-reflection

Personal Competencies

Social Competencies

Communication

Leadership and Responsibility

Self-presentation and Social Influence

Current Immunological Research in Zurich

This monthly meeting is a platform for Zurich-based immunology research groups to present and discuss their ongoing research projects. At each meeting three PhD students or Postdocs from the participating research groups present an ongoing research project in a 30 min seminar followed by a plenary discussion.

Z Dr 0 credits 1K

R. Spörrti, C. Halin Winter, W.-D. Hardt, M. Kopf, S. R. Leibundgut, A. Oxenius, University lecturers

Abstract

Objective

Content

Prerequisites / notice

Competencies
Presentation and discussion of current research projects carried out by various immunology-oriented research groups in Zurich.

Objective
The aim of this monthly meeting is to provide further education for master and doctoral students as well as Postdocs in diverse topics of immunology and to give an insight in the related research. Furthermore, this platform fosters the establishment of science- and technology-based interactions between the participating research groups.

551-1106-00L Progress Reports in Microbiology and Immunology

Students must sign up via secr.micro.biol.ethz.ch

Abstract
Presentation and discussion of current research results in the field of Microbiology and Infection Immunology

Objective
Precise and transparent presentation of research findings in relation to the current literature, critical discussion of experimental data and their interpretation, development and presentation of future research aims.

551-0209-00L Sustainable Plant Systems (Seminar)

Abstract
Agriculture, food and waste management should use less resources to accept the planetary boundaries. The focus of the seminar is:

(1) Agroecological systems. Can we transform the impact of agricultural in Switzerland and beyond?
(2) Food system transformation. How can local sustainable food systems be built and scaled through policy strategies, food environments and consumer habits.

Objective
Participants will be able to:

(1) Review issues of sustainability in the context of plant science research and literature on sustainable agriculture and the food system.
(2) Analyse and interact on several case studies on agro-ecology and the food system.

Content
Future society has to feed nine billion people, therefore agriculture and food, waste and resource management have to go hand in hand toward the use of less resources and acceptance of the limits of Planetary Boundaries. The focus of the seminar will be:

(1) Research in agroecological systems. How can we transform the impact of agricultural in Switzerland and beyond?
(2) Food system transformation. How can local sustainable food systems be built and scaled through policy strategies, food environments and consumer habits.

The seminar will have (a) two face-to-face sessions, (b) self-organized group work phase with case studies that will be analyzed by student groups and results be presented, (c) participants will publish a report in the ETHZ-PSC Science and Policy Blog on their findings.

551-0120-00L Plant Biology Colloquium (Spring Semester)

Objective
Current topics in Molecular Plant Biology presented by internal and external speakers from academia.

Content

551-0120-01L Plant Biology Colloquium (Autumn Semester)

Abstract
This compulsory course only once. It may be taken in autumn as course 551-0120-00 "Plant Biology Colloquium (Autumn Semester)" or in spring as course 551-0120-01 "Plant Biology Colloquium (Spring Semester)".

Objective
Getting insight into actual areas and challenges of Molecular Plant Biology.

Content

551-1615-00L NMR Methods for Studies of Biological Macromolecules

Prerequisites: Basic knowledge in biological NMR spectroscopy.

Abstract
In this seminar series, topics relevant to solution state NMR with biological macromolecules are treated. Each semester a different aspect of biomolecular NMR is discussed in depth. The course is tailored to advanced students (PhD students and postdocs) who have experience with applications of NMR spectroscopy. Each participant presents a selected topic in form of a seminar.

Objective
The students will actively participate in the course which is held in form of a seminar. Individual students will prepare particular topics of the course based on literature references and present the material in form of a seminar to their fellow students. In short, the students learn to actively participate in discussions and to prepare a presentation of a scientific topic which was mostly unknown to them before.
**Competencies**

### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

### Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies

### Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Sensitivity to Diversity

### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

### Current Topics in Molecular Health Sciences
- **Z 0 credits 2S**
  - **I. Zanini,** further lecturers

**Abstract**
This course is a seminar series on current research topics within the Institute of Molecular Health Sciences.

**Objective**
The course introduces the participants to recent developments in the fields of molecular health sciences.

### Lecture Series: Space Research and Exploration
- **Z Dr 1 credit 2V**
  - **S. P. Quanz**

**Abstract**
Lecture Series about selected topics of space research and exploration consisting of individual talks given by different leading experts from academia and industry.

**Objective**
- Attending students will
  - experience the interdisciplinarity of space research and exploration spanning physics, engineering, geosciences, biology and more
  - get familiar with the Swiss space research and industry landscape
  - enhance their communication skills by broadening their research horizon
  - have the opportunity for direct learning by posing questions to experts

**Content**
The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay between the scientifically desirable and the technologically possible. The Lecture Series: Space Research and Exploration aims to shed light on key questions engaged by leading scientists and engineers today. It consists of weekly lectures, given by different speakers with vast experience in their respective field (e.g., Human Spaceflight, System Engineering of Spacecraft, Space Life Sciences, Space-based astrophysics). Subsequent to the talk, the student will have the opportunity to deepen their understanding by asking questions to the presenter in a moderated Q&A.

Confirmed speakers will be announced by the start of the semester (see lecture from last year for previous speakers).

### Competencies

### Biology (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td></td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td></td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td></td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Biology Bachelor

#### First Year Courses

#### First Year Examinations

#### First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0125-00L</td>
<td>Fundamentals of Biology I: From Molecules to the Biochemistry of Cells</td>
<td>O</td>
<td>6</td>
<td>5G</td>
<td>J. Vorholt-Zambelli, N. Ban, R. Glockshuber, K. Locher, J. Piel</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts.

**Objective**
Introduction to biochemistry, molecular biology and evolutionary principles

**Content**
The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that operate within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biology are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

**Lecture notes**
The newly conceived lecture is supported by scripts.

**Literature**
The lecture is supported by scripts.

**Competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Problem-solving, Critical Thinking, Self-awareness and Self-reflection
- Method-specific Competencies: Assessed

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-1001-01L</td>
<td>General Chemistry (for Biol./Pharm.Sc.)</td>
<td>O</td>
<td>4</td>
<td>4V+2U</td>
<td>J. Cvengros</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetics, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.

**Objective**
The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.

**Literature**
- Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(englisch)

**Competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Decision-making, Problem-solving
- Method-specific Competencies: Assessed

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-1011-00L</td>
<td>Organic Chemistry I (for Biol./Pharm.Sc./HST)</td>
<td>O</td>
<td>4</td>
<td>4G</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

**Abstract**
Fundamentals of Organic Chemistry: molecular structure. Bonding and functional groups; nomenclature; resonance and aromaticity; stereochemistry; conformation; bond strength; organic acids and bases; basic reaction thermodynamics and kinetics; reactive intermediates: carbanions, carbenium ions and radicals.

**Objective**
Understanding the basic concepts and definitions of organic chemistry. Knowledge of the functional groups and classes of compounds that are important in biological systems. Foundations for the understanding of the relationship between structure and reactivity.

**Content**

**Lecture notes**
Lecture notes are available (pdf file). Exercises, answer keys and other handouts can be downloaded from the Moodle course "Organic Chemistry I" of the current semester (https://moodle.app2.let.ethz.ch).
Literature

Prerequisites / notice
The course consists of lectures (36 hours) and problem-solving lessons (20 hours, groups of ca. 25 people). In addition, online exercises are available in the e-learning environment Moodle (Course OC I).

Competencies
- Subject-specific Competencies
- Concepts and Theories
- Method-specific Competencies
- Analytical Competencies
- Social Competencies
- Communication
- Personal Competencies
- Creativity
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0073-00L</td>
<td>Physics I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+2U</td>
<td>T. M. Ihn</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics and elements of quantum mechanics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Students know and understand the basic ideas of the scientific description of nature. They understand the fundamental concepts and laws of mechanics and they are able to apply them in practical problems. They know the concepts of quantization and quantum numbers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Content  | 1. Description of Motion  
2. The laws of Newton  
3. Work and energy  
4. Collision problems  
5. Wave properties of particles  
6. The atomic structure of matter |
| Lecture notes | T. Ihn: Physics for Students in Biology and Pharmaceutical Sciences (unpublished lecture notes) |

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
<td></td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>fostered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
<td></td>
</tr>
</tbody>
</table>

| 401-0291-00L | Mathematics I            | O    | 6 credits | 4V+2U | E. W. Farkas |
| Abstract    | Mathematics I/II is an introduction to one- and multidimensional calculus and linear algebra emphasizing on applications. |
| Objective   | Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences. Students can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems. |
## Eindimensionale diskrete Entwicklungen ##
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsraten
- Folgen und Grenzwerte

## Funktionen in einer Variablen ##
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

## Differentialrechnung (I) ##
- Veränderungsraten-/geschwindigkeit
- Differentialquotient und Ableitungsfunktion
- Anwendungen der Ableitungsfunktion

## Integralrechnung (I) ##
- Stammfunktionen
- Integrationstechniken

## Gewöhnliche Differentialgleichungen (I) ##
- Qualitative Beschreibung an Beispielen:
  - Beschränkt, Logistisch, Gompertz
  - Stationäre Lösungen
  - Lineare DGL 1. Ordnung
  - Trennung der Variablen

## Lineare Algebra ##
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

Lecture notes
In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem Vademecum zusammen.

Dabei gilt:
* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

Literature
Siehe auch Lernmaterial > Literatur

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände:
Einführung in die Analysis, Einführung in die Lineare Algebra;
Haupt-Verlag Bern, UTB.

**H. H. Storrer**
Einführung in die mathematische Behandlung der Naturwissenschaften I; Birkhäuser.
Via ETHZ-Bibliothek:
https://link.springer.com/book/10.1007/978-3-0348-8598-0

**Ch. Blatter**
Lineare Algebra; VDF und als Skript in der PolyBox

**A. Caspar, N. Hungerbühler**
Mathematische Modellierung in den Life Sciences, Springer.
Via ETH-Bibliothek:

Prerequisites / notice

## Übungen und Prüfungen ##
+ Die Übungsaufgaben (Handaufgaben, Khan-Aufgaben, Multiple-Choice) sind ein wichtiger Bestandteil der Lehrveranstaltung.
+ Es wird erwartet, dass Sie mindestens 9 von 13 der wöchentlichen Serien bearbeiten und zur Korrektur einreichen.
+ Der Prüfungsstoff ist eine Auswahl von Themen aus Vorlesung und Übungen. Für eine erfolgreiche Prüfung ist die konzentrierte Bearbeitung der Aufgaben unerlässlich.

Competencies

<table>
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First Year Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 273 of 2667
Laboratory Course General Chemistry (for Biology and Pharmacy) 

Information about the practical course will be given on the first day.

Register in myStudies as early as possible, because the fire protection courses take place separately before the internship starts.

Abstract
Introduction to the practical work in a chemistry laboratory. The most important manipulations and techniques are treated, as well as the most fundamental chemical reaction types.

Objective
- Knowledge of the basic chemical laboratory methods
- Basic knowledge of the scientific approach in experimenting
- Observation and interpretation of chemical processes
- Keeping of a reliable laboratory journal

Content
- Simple chemical working techniques/methods
- Separation techniques
- Physical measurements: mass, volume, pH
- Ionic solids (salts)
- Acid/base chemistry, buffers
- Redox reactions
- Metal complexes
- Titration methods and quantitative spectrometry
- Introduction to qualitative analysis

Lecture notes
Course manual in German (is handed out to the students at the begin of the lessons)

Language: German, English upon request

Literature

is a suitable textbook.

Prerequisites / notice
This practical course causes costs for materials and chemicals. The costs are charged to the students at the end of semester.

By enrolling in this lab course, students confirm that they will thoroughly study and follow all safety information and instructions and that they have an accident insurance valid for Switzerland for the entire duration of the semester.

Competencies
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<tr>
<td>Problem-solving</td>
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<td>fostered</td>
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</tbody>
</table>

Social Competencies
Communication fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Advanced Course in Physical Chemistry

Number  Title                                    Type  ECTS  Hours  Lecturers

Abstract
The lecture conveys the fundamental concepts underlying multicellularity with an emphasis on the molecular basis of multicellular biological systems and their functional integration into coherent wholes. The structural and functional specialization in multicellular organisms will be discussed by highlighting common and specific functions in fungi, plants, and animals (including humans).

Objective
1. Students can describe advantages and challenges associated with being multicellular and outline independent solutions that organisms have developed to cope with the challenges of complex multicellularity
2. Students can explain how the internal and external structures of fungi, plants and animals function to support survival, growth, behavior, and reproduction.
3. Students can explain the basic pathways and mechanisms of cellular communication regulating cellular behavior (cell adhesion, metabolism, proliferation, reproduction, development).
4. Students can describe how a single cell develops from one cell into many, each with different specialized functions.

Content
The lecture introduces the structural and functional specialization in fungi, plants and animals, including humans. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi, plants, animals and humans have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, human anatomy and physiology, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development.

Literature
Alberts et al. 'Molecular Biology of the Cell' 6th edition
Campbell 'Biology', 11th Edition

Prerequisites / notice
Some lecture are held in English.

Competencies
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<tr>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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</table>

Social Competencies
Creative Thinking fostered
Critical Thinking assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered
Bioanalytics

Abstract
The course will introduce students to a selected set of laboratory techniques that are foundational to modern biological research.

Objective
For each of the techniques covered in the course, the students will be able to explain:
- the physical, chemical and biological principles underlying the technique,
- the requirements for the sample,
- the type of raw data collected by the technique,
- the assumptions and auxiliary information used in the interpretation of the data and
- how these data can be used to answer a given biological question.

By the end of the course the students will be able to select the appropriate experimental technique to answer a given biological problem and will be able to discuss the advantages and limitations of individual techniques as well as how different techniques can be combined to gain a more complete understanding of a given biological questions.

Content
The course will be based on a combination of lectures, self-study elements and exercises.

The focus will be on the following experimental techniques:
- DNA sequencing
- chromatography
- mass-spectrometry
- UV/Vis and fluorescence spectrometry
- light microscopy
- electron microscopy
- X-ray crystallography
- NMR spectroscopy

Lecture notes
The course is supported by a Moodle page that gives access to all supporting materials necessary for the course.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection

Foundations of Computer Science

Abstract
This course provides selected computer science concepts for interdisciplinary projects.

Objective
Students learn to:
- encode a problem into a program, test the program, and correct errors.
- understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- query databases and understand and evaluate the corresponding database model.
- implement models from the natural sciences as a simulation.
- run random experiments and interpret the results.
- explain and apply standard algorithms and evaluate their efficiency.

Content
1. Variables, data types
2. Control structures, logic
3. Sequential data types, search- and sort algorithms, sequence analysis
4. Functions, modules, simulation and animation
5. Manage data with a relational database
6. Matrices, random experiments, cellular automata

Lecture notes
All materials for the lecture are available at www.gdi.ethz.ch

Literature

Prerequisites / notice
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Statistics II

Abstract

Objective

Content

Lecture notes

Literature

Prerequisites / notice

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
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Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

J. Dambon
Vertiefung von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

**Objective**


**Content**

- 1. Evaluation of chemical equilibria based on chemical potential
- 2. Interpretation of phase diagrams
- 3. Which interactions between molecules are important in living cells
- 4. Why molecules self-organize into aggregates
- 5. Which physical-chemical basics determine behavior of biomembranes
- 6. What determines the rate of chemical reactions, in particular also of enzymatically catalyzed reactions
- 7. What determines the transport rate of matter and heat

**Lecture notes**

A lecture script is provided

**Literature**

In addition to the lecture script, the following two books can be used to gain deeper understanding


The basic reactions of Organic Chemistry and their mechanisms should be known and the corresponding exam have been passed (cf. course 529-1012-00L Organic Chemistry II for Students of Biology, Pharmaceutical Sciences, and Health Sci. and Tech.).

The prerequisite for passing is the ETH security exam.

By enrolling in this lab course, students confirm that they have thoroughly studied all safety information and will follow all instructions.

Competencies

Subject-specific Competencies
- Concepts and Theories
  - assessed
- Techniques and Technologies
  - assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
- Media and Digital Technologies
  - fostered

Social Competencies
- Communication
  - fostered
- Cooperation and Teamwork
  - fostered
- Self-presentation and Social Influence
  - fostered
- Sensitivity to Diversity
  - fostered

Personal Competencies
- Adaptability and Flexibility
  - fostered
- Creative Thinking
  - fostered
- Critical Thinking
  - fostered
- Integrity and Work Ethics
  - fostered
- Self-awareness and Self-reflection
  - fostered
- Self-direction and Self-management
  - fostered

Literature

1) P. Wörfel, M. Bitzer, U. Claus, H. Felber, M. Hübel, B. Vollenweider, Laborpraxis (Bd. 1: Einführung, allgemeine Methoden; Bd. 2: Messmethoden; Bd. 3: Trennungsmethoden; Bd. 4: Analytische Methoden); Birhäuser Verlag; Basel; 1990.

Prerequisites / notice

The aim of the course is to provide students with a solid introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Method of instruction

The methods of instruction include lectures, exercises, and exams. Students will be assessed on their understanding of the course material, their ability to apply it to real-world problems, and their ability to work cooperatively in a team environment.

Literature


Handouts

The handouts are available online and will be distributed to students at the beginning of the course. They will be used in class to cover the course material and to supplement the textbook.

Prerequisites

Before enrolling in this course, students must have completed at least one course in mathematics and one course in biology. They must also have a strong interest in the subject matter and be willing to put in the necessary effort to succeed.

Assessment

Assessment will be based on a combination of exams, assignments, and participation in class. The final grade will be calculated based on the following criteria: 30% for the first exam, 30% for the second exam, 30% for the third exam, and 10% for participation and homework assignments.

Handouts

The handouts are available online and will be distributed to students at the beginning of the course. They will be used in class to cover the course material and to supplement the textbook.

Lecturers

T. Städler, A. Widmer, S. Fior, M. Fischer, J. Stapley

ECTS

6 credits

Type

W

Handouts

The handouts are available online and will be distributed to students at the beginning of the course. They will be used in class to cover the course material and to supplement the textbook.

Subject-specific Competencies

- Concepts and Theories
  - assessed
- Techniques and Technologies
  - assessed

Method-specific Competencies

- Analytical Competencies
  - assessed
- Media and Digital Technologies
  - fostered

Social Competencies

- Communication
  - fostered
- Cooperation and Teamwork
  - fostered
- Self-presentation and Social Influence
  - fostered
- Sensitivity to Diversity
  - fostered

Personal Competencies

- Adaptability and Flexibility
  - fostered
- Creative Thinking
  - fostered
- Critical Thinking
  - fostered
- Integrity and Work Ethics
  - fostered
- Self-awareness and Self-reflection
  - fostered
- Self-direction and Self-management
  - fostered

Information for UZH students:

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Data: 02.07.2024 12:39
Autumn Semester 2024
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**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics.

**Content**

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**

Scripts and additional material will be provided during the semester.

**Competencies**

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**551-0311-00L Molecular Life of Plants**

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**Abstract**

The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence.

**Objective**

The new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels.

The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.

**Content**

The course "Molecular Life of Plants" will cover the following topics:

- Seed structure and physiology, their dormancy and germination.
- Seedling establishment and early development.
- Plant reproroduction.
- Structure and Function of Meristems, including stem cells.
- Plant organ development (leaves, roots, flowers etc.).
- Plant-microbe interactions; beneficial friends or pathogenic foes?
- Polyploidy; the benefits, problems and solutions to of multiple genomes.
- Photosynthesis and carbon partitionning.
- Photosynthesis and the evolution of C4 metabolism.
- Starch biosynthesis and degradation.
- Chloroplast development and chlorophyll biosynthesis.
- Senescence mechanisms in plants.
- General principles of RNA silencing.
- MicroRNAs: discovery, general principle and modes of action at the cellular and system levels.
- Chromatin-based RNA silencing.
- Antiviral RNA silencing.
- RNA silencing movement and amplification.

**Competencies**

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**551-0313-00L Microbiology (Part I)**

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**Abstract**

Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Objective**

This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Content**

Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Lecture notes**

Updated handouts will be provided during the class.

**Prerequisites / notice**

The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.
Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Competencies

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<tr>
<td>551-0317-00L Immunology I</td>
<td>W 3 credits</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
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</tbody>
</table>

Abstract
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Objective
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity. Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Competencies

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<tr>
<td>551-1299-00L Bioinformatics</td>
<td>W 6 credits</td>
<td>4G</td>
<td>S. Sunagawa, P. Beltrao, V. Boeva, A. Kahles, C. von Mering, N. Zamboni</td>
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Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R. Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.
Adaptability and Flexibility fostered

ECTS
Mainly based on original literature, a detailed list will be distributed during the lecture and will include topics such as pathway elucidation & engineering and related ongoing research projects in the lab.

Nucleic Acids and Carbohydrates will be provided at the beginning of the course.

6 credits assessed

K. Lang

Adaptability and Flexibility fostered

Subject-specific Competencies
Communication assessed

Analytical Competencies assessed

Critical Thinking assessed

Decision-making assessed

Cooperation and Teamwork fostered

Media and Digital Technologies assessed

Self-awareness and Self-reflection fostered

Problem-solving assessed

Self-direction and Self-management fostered

Project Management fostered

Social Competencies

Personal Competencies

Adaptability and Flexibility fostered

Creative Thinking assessed

Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered

Cooperation and Teamwork assessed

Self-direction and Self-management assessed


can be counted for the Bachelor's degree.

529-0730-00L Nucleic Acids and Carbohydrates

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Mainly based on original literature, a detailed list will be distributed during the lecture.

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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Self-awareness and Self-reflection</td>
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<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Self-direction and Self-management</td>
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<td>Project Management</td>
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</table>

529-0731-00L Nucleic Acids and Carbohydrates

W 6 credits 3G K. Lang, M. Frei, P. A. Kast, H. Wennemers

Block Courses

Registration for Block courses is mandatory. Please register under https://www.mybiportal.uzh.ch. Registration period: from 22.07.2024 - 09.08.2024

Please note the ETH admission criteria for the admission of ETH students to ETH block courses on the block course registration website under “allocation”.

Block Courses in 1st Quarter of the Semester

From 17.09.2024 to 9.10.2024

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-1129-00L</td>
<td>Understanding and Engineering Microbial Metabolism</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>J. Vorholt-Zambelli</td>
</tr>
<tr>
<td>551-1421-00L</td>
<td>The Mechanisms of Natural Transformation in Competent Gram-Negative Bacteria</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>M. Hospenthal</td>
</tr>
</tbody>
</table>

Number of participants limited to 6.

The enrolment is done by the D-BIOL study administration.

The focus of this laboratory course is on current research topics related to metabolic engineering and the general understanding of metabolism, particularly in relation to one carbon metabolism. Projects will be carried out in small teams.

The course aims at introducing technologies to investigate bacterial metabolism and key principles of metabolic engineering. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular genetic, biochemical and analytical techniques including metabolomics. Results will be presented by students in scientific presentations. Another goal is to learn how to write a scientific report.

The course will include topics such as pathway elucidation & engineering and related ongoing research projects in the lab. Experimental work applied during the course will comprise methods such as cloning work & transformation, growth determination, enzyme activity assays, liquid-chromatography mass-spectrometry and dynamic labeling experiments.

None

Will be provided at the beginning of the course.

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Problem-solving assessed

Communication assessed

Cooperation and Teamwork assessed

Adaptability and Flexibility fostered

Critical Thinking fostered

Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered

Self-direction and Self-management assessed

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Problem-solving
Communication
Cooperation and Teamwork
Adaptability and Flexibility
Critical Thinking

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.
Students will carry out defined research projects related to the current research topics of the Hospenthal group. The topics will include protein expression of pilins and/or other competence proteins from Gram-negative bacteria, protein purification using affinity chromatography, crystallisation experiments and analysis of assembled pili by electron microscopy.

The enrolment is done by the D-BIOL study administration.

Students will be tutored in their experimental work by an experienced doctoral student. The course will also include a short lecture delivered by M. Hospenthal, providing the theoretical background for the experimental work. Throughout the course, students will receive exercises that further help to explain the theory of the practical work, as well as literature research tasks.

Participation in the following Hospenthal lab projects will be possible:
- Purification, biophysical characterisation and structure determination of pilins
- Purification, biophysical characterisation and structure determination of proteins and protein complexes involved in natural transformation.

Experimental work on this project involves:
- Cloning and mutagenesis
- Recombinant or endogenous protein production in E. coli or Legionella
- Protein purification by affinity chromatography (other chromatographic purification techniques will also be discussed)
- Protein crystallisation and crystal optimisation
- Visualisation of bacterial pili by electron microscopy (negative stain or cryo electron microscopy)
- DNA binding experiments
- Enzymatic activity measurements
- In silico structural analyses using PyMOL and Chimera

Any required reading of literature will be discussed at the beginning of the course.

551-0337-00L  
Cell Biology of the Nucleus  
W 6 credits  7P  R. Kroschewski, Y. Barral,  
M. Jagannathan, S. Jessberger, K. Weis

Number of participants limited to 14.

The enrolment is done by the D-BIOL study administration.

The aim of our course is to introduce the students to the organizational principles of the nucleus using budding yeast, drosophila and vertebrate cells as model systems. Emphasis is given to:
- Establishment of nuclear identity and nuclear-cytoplasmic communication
- Reorganization of the nucleus in aging
- Animal cells during the generation of cell diversity and neuronal differentiation

By the end of the course, based on lectures, literature reading and practical lab work, the students will be able to formulate open questions concerning the function of the nucleus. Thus, the students will know about the mechanisms and consequences of nuclear-cytoplasmic compartmentalization, DNA clustering in the nucleus and cytoplasm during cell divisions and aging.

During this block-course, the students will
- learn how organelles establish and maintain identity with a focus on the nucleus
- discover the evolutionary and functional plasticity of the nucleus
- design, apply, evaluate and compare experimental strategies

Students - in groups of 2 or max. 3 - will be integrated into a research project connected to the subject of the course, within one of the participating research groups.

Lectures and technical notes will be given and informal discussions held to provide you with the theoretical background.

Optional papers linked to the projects shall support you in that choice. They can also serve as framework orientation for the practical parts of this block course.

Documentation and recommended literature (review articles) will be provided during the course.
### Creative Thinking

**Concepts and Theories**

- Insight into and overview about the genetic and metabolic alterations that underlie different cancer types, the complex cancer cell circuitries governing tumor development, progression, and metastasis. Understanding of modern approaches used in contemporary basic and translational cancer research and sophisticated strategies to control individual cancers and combat drug resistance. The course is closely linked to ongoing research projects in the lab to provide the participants with direct insights into current experimental approaches and strategies. Student assessment is a graded performance based on individual performance in the laboratory, a written report of their data and a presentation of a recent paper published in a top ranking international peer reviewed journal that relates to cancer.

**Method-specific Competencies**

- Perform quantitative proteomic analysis (protein identification with Mascot and/or Sequest Softwares)
- Perform qualitative proteomic analysis (label-free and labeled analyses)

**Social Competencies**

- Communication
- Cooperation and Teamwork

**Personal Competencies**

- Critical Thinking

### Introduction to Mass Spectrometry-Based Proteomics

**Number of participants limited to 12.**

- The enrolment is done by the D-BIOL study administration.

**Abstract**

- Protein Analysis by Mass Spectrometry

**Objective**

- How to prepare a protein sample for MS analysis (trypsin digestion, C18 clean-up)
- Principles of data acquisition LC-MS (QTOF and/or Ion Trap instruments)
- Perform qualitative proteomic analysis (protein identification with Mascot and/or Sequest Softwares)
- Perform quantitative proteomic analysis (label-free and labeled analyses)
- Analyze/interpret the data to find up/down regulated proteins

**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Cooperation and Teamwork
- Personal Competencies: Critical Thinking

### Block Courses in 2nd Quarter of the Semester

**From 10.10.2024 to 1.11.2024**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0345-00L</td>
<td>Mechanisms of Bacterial Pathogenesis</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>W. Hardt, B. Nguyen</td>
</tr>
</tbody>
</table>

**Abstract**

- Research laboratory class in small groups. Research projects on current topics in cellular microbiology and bacterial pathogenesis are assigned to each student.

**Objective**

- Introduction to a current topic in cellular microbiology, molecular genetics of a bacterial pathogen or its interaction with the host's microbiome. Experimental work in the research lab and introduction to the current lab techniques. This includes contributions to the analysis of animal experiment. You will work with the current research literature in bacterial pathogenesis and write a research protocol.

**Requirement for obtaining the credit points:** oral presentation of the research project, a short written exam and evaluation of the research protocol.

**Content**

- Research projects on the model pathogen Salmonella.

**Lecture notes**

- none.

**Literature**

- Literature will be selected with reference to the assigned research project.

**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Adaptability and Flexibility

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 282 of 2667
Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their

**Objective**

Knowledge of the fungi of forest and its ecological significance. Knowing of current methodological research approaches. Self-reliant and deepened activities of selected topics of fungi from forests.

**Content**

Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

**Lecture notes**

Unterlagen zum Kurs werden abgegeben.

**Literature**


**Prerequisites / notice**

Der Blockkurs findet an der Eidg. Forschungsanstalt WSL in Birmensdorf statt. Der Wald vor der Haustüre des Institutes macht diesen Kurs besonders praxisnah.

Erreichbarkeit mit Tram 14 bis Triemli, danach PTT-Bus 220 oder 350 bis Birmensdorf Sternen/WSL, oder mit S9 bis Birmensdorf SBB und mit PTT-Bus eine Station in Richtung Zürich bis Birmensdorf Sternen/WSL.

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

**Personal Competencies**

- Adaptable and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed

**Computational Methods in Genome and Sequence Analysis**

This course aims to provide students with a comprehensive overview of computational methods for sequence analysis and assist with developing skills for application of computational approaches by experimental scientists in the life sciences.

**Objective**

Methods for analyzing animal genomes are increasingly becoming important for applications in human health and biotechnology suggesting that the experience will be useful to develop relevant expertise for a broad range of functions. Students will have the opportunity to advance their knowledge in programming by focusing on algorithms for genome and gene sequence analysis. A major goal of the course will be to lead the student to an independent and empowered attitude towards computational problems. For reaching this goal the students will work on an implementation of a solution for a set real-world problem in genome and sequence analysis under guided supervision.
The course will consist of a series of lectures, assignments for implementing elementary tasks in Python, project development and discussion workshops, and 3 and a half week of practical work implementing a Python script as a solution to a real world problem associated with sequence analysis. At the end of the course students will explain their solutions and demonstrate the functionality of their implementations, which will then be discussed and commented on by the group. It is expected that students will be able to apply the knowledge to improve on concrete problems.

Prerequisites / notice
- It is recommended to bring your own computer with a Python installation to the course
- simple computers can be provided
- Programming basics with Python

Competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies

Communication
Cooperation and Teamwork

Personal Competencies

Negotiation
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

551-0359-00L  Plant Biochemistry

Number of participants limited to 11.
The enrolment is done by the D-BIOL study administration.

Objective

Students are able to independently apply and record current molecular biology methods on plants, critically evaluate and communicate the results, understand the larger context of their research project and develop ideas for further experiments.

Content

Projects are newly designed each year and announced a few days before the course starts. Possible projects include the cell biology of starch granule formation (using fluorescence and electron microscopy and protein-protein interaction studies) or RNA metabolism in chloroplasts (using import assays and RNA detection).

Lecture notes
No script

Literature
Descriptions of the possible projects including individual reading suggestions will be handed out beforehand.

Competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies

Communication
Cooperation and Teamwork

Personal Competencies

Negotiation
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

551-1609-00L  Single Molecule Biophysics Studies of the Microtubule Cytoskeleton

Number of participants limited to 5.
The enrolment is done by the D-BIOL study administration.

Abstract

This laboratory course has a focus on current research topics in our laboratory related to microtubule nucleation and dynamics and its investigation using in vitro reconstitutions and single molecule biophysics. Projects will be conducted in small groups.

Objective

The course aims to introduce technologies to investigate cytoskeletal processes and regulation using in vitro reconstitutions and single molecule biophysics methods. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular protein purification and biophysical techniques including single molecule fluorescence imaging using Total Internal Reflection Fluorescence Microscopy (TIRFM) and subsequent image analysis methods. Results will be presented by students in scientific presentations. Another goal is to learn how to write a scientific report.
In this block course we will prepare proteins bearing site-specifically installed post-translational modifications using genetic code expansion. The course will include topics such as microtubule polymerization dynamics and related ongoing research projects in the lab. Experimental work applied during the course will comprise methods such as cloning work & transformation, protein purification, single molecule fluorescence imaging using Total Internal Reflection Fluorescence Microscopy (TIRFM), and single molecule image analysis.

Objective
Students will learn basic techniques for genetic code expansion. They will learn how to synthesize non-canonical amino acids (ncAAs), manipulate plasmids through cloning techniques to introduce an amber codon at a user defined site in a gene of interest, express and purify recombinant proteins bearing site-specific ncAAs using state-of-the-art chromatographic techniques, characterize the target protein using mass spectrometry and analyze the properties of the target protein regarding enzymatic activity and protein-protein interactions using biophysical techniques.

Content
During this block course, the participants will study the impact of different post-translational modifications (PTMs) on protein function using genetic code expansion. The participants will work in teams of two, will first synthesize different ncAAs mimicking PTMs, such as acylated lysine derivates (e.g. acetylylsine, butryllysine etc.). These ncAAs will be incorporated into target proteins using orthogonal aminoacyl tRNA synthetase / tRNA pairs, which direct the site-specific incorporation in response to an in frame introduced amber stop codon (amber suppression). Therefore, the participants will introduce the amber stop codon at different positions in the gene of interest using standard molecular cloning techniques. After recombinant expression of the target protein, the participants will isolate the ncAA-bearing target proteins using different chromatography techniques using a FPLC system. After characterization of the PTM-bearing protein using mass spectrometry, the participants will study the impact of the PTM on enzymatic activity and protein-protein interactions using biophysical techniques.

Prerequisites / notice
This laboratory block course is designed for 3 weeks, 3.5 days. Students should have basic practical knowledge in organic synthesis, molecular cloning, protein expression and purification (participants must have attended the practical course BCB-IV prior to this block course). The maximum number of participants is currently limited to 8. Interested applicants may contact Dr. M. Fottner for further information. Commitment for attendance of entire course is necessary. The course cannot be interrupted by individual absences once started.

Lecture notes
All the required theoretical and experimental informations can be found in the provided script. Details will be discussed in class. Relevant research papers will be recommended for reading during the seminars.

Enrolment limited to max 8 students. The enrolment is done by the D-BIOL study administration.

Abstract
In this block course we will prepare proteins bearing site-specifically installed post-translational modifications using genetic code expansion. The impact of the post-translational modifications on enzymatic activity and protein-protein interactions will be studied.

Lecturers
K. Lang, M. Fottner

ECTS
6 credits

W  6 credits  7P

529-0044-00L

Genetic Code Expansion for Studying Posttranslational Modifications

Concepts and Theories fostered
Techniques and Technologies fostered
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Social Competencies

Personal Competencies

Method-specific Competencies

Subject-specific Competencies

Content:
The course will include topics such as microtubule polymerization dynamics and related ongoing research projects in the lab. Experimental work applied during the course will comprise methods such as cloning work & transformation, protein purification, single molecule fluorescence imaging using Total Internal Reflection Fluorescence Microscopy (TIRFM), and single molecule image analysis.

Competencies:
The course will prepare proteins bearing site-specifically installed post-translational modifications using genetic code expansion. The course will include topics such as microtubule polymerization dynamics and related ongoing research projects in the lab. Experimental work applied during the course will comprise methods such as cloning work & transformation, protein purification, single molecule fluorescence imaging using Total Internal Reflection Fluorescence Microscopy (TIRFM), and single molecule image analysis.

Block Courses in 3rd Quarter of the Semester

From 5.11.2024 to 27.11.2024

Number
Title
Type
ECTS
Hours
Lecturers

529-0739-01L
Biological Chemistry B: New Enzymes from Directed Evolution Experiments

W
6 credits
7P
P. A. Kast, M. Levasseur

The enrolment is done by the D-BIOL study administration.

Abstract
During the block course in the fall semester, we will carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. By working in parallel, teams of 2 participants each will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include the determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The results obtained from the individual evolution experiments will be compared and discussed at the end of the class in a final seminar. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalysts.

Lecture notes
A script will be distributed to the participants on the first day of the course.
I. Zemp
M. Schuppler

Introduction to the physiological and biochemical action of insulin signaling and its role in the fasted/feeding response and in obesity and diabetes.

Further literature will be indicated in the distributed script.

Prerequisites / notice
This laboratory course will involve experiments that require a tight schedule and, particularly in the second half, very long (!) working days. The maximum number of participants for the laboratory class is limited, but surplus applicants may contact P. Kast directly to have their names added to a waiting list. A valid registration is considered a commitment for attendance of the entire course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast. For more information see http://www.kast.ethz.ch/teaching.html, from where you can also download a flyer.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered

Personal Competencies
Adaptability and Flexibility assessed
Critical Thinking fostered
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed

Methods in Cellular Biochemistry
551-0336-00L
Methods in Cellular Biochemistry
Number of participants limited to 19.
The enrolment is done by the D-BIOL study administration.

Abstract
Students will learn about biochemical approaches to analyze cellular functions. The course consists of practical projects in small groups, lectures and literature discussions. The course concludes with the presentation of results at a poster session.

Objective
Students will learn to design, carry out and assess experiments using current biochemical and cell biological strategies to analyze cellular functions in model systems. In particular they will learn novel imaging techniques along with biochemical approaches to understand fundamental cellular pathways. Furthermore, they will learn to assess strengths and limitations of the different approaches and be able to discuss their validity for the analysis of cellular functions.

Literature
Documentation and recommended literature (review articles and selected primary literature) will be provided during the course.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Insulin Signaling
551-1515-00L
Insulin Signaling
Number of participants limited to 15.
The enrolment is done by the D-BIOL study administration.

Abstract
Introduction to the physiological and biochemical action of insulin signaling and its role in the fasted/feeding response and in obesity and diabetes.

Objective
The students will obtain an overview about the current topics of research in insulin signaling and how it impacts on growth, metabolism and cell differentiation. They will learn to design experiments and use techniques necessary to analyze different aspects of insulin signaling, including physiological actions in whole animals as well as in tissue culture. Through lectures and literature seminars, they will learn about the open questions of insulin signaling research and discuss approaches to address these questions experimentally.

In practical lab projects the students will perform physiological in vivo studies as well as biochemical experiments. Finally, they will learn how to present and discuss their data. Student assessment is a graded semester performance based on individual performance in the laboratory, a written exam and the lab data presentation.

Experimental Food Microbiology for Biologists
752-4020-00L
Experimental Food Microbiology for Biologists
Number of participants limited to 12.
Minimum number of participants: 6 (below this number the course will be cancelled)
The course can only be booked via the Biology Student secretariat.

Number of participants limited to 20.
The enrolment is done by the D-BIOL study administration.

Abstract
Introduction to food microbiology, covering food spoilage, foodborne pathogens and the psychrophilic microbiome of aquatic systems.

Objective
The students will obtain an overview about the current topics of research in food microbiology and how it impacts on food quality and safety. They will learn to design experiments and use techniques necessary to analyze different aspects of food microbiology, including physiological actions in whole animals as well as in tissue culture. Through lectures and literature seminars, they will learn about the open questions of food microbiology research and discuss approaches to address these questions experimentally.

In practical lab projects the students will perform physiological in vivo studies as well as biochemical experiments. Finally, they will learn how to present and discuss their data. Student assessment is a graded semester performance based on individual performance in the laboratory, a written exam and the lab data presentation.
Teaching of basic experimental knowledge for detection and identification of microorganisms in food. Practical experiments were accompanied by theoretical introductions. Students become acquainted with classical and state-of-the-art molecular techniques for the rapid detection of foodborne pathogens and experiments in dependence on current research topics of the Laboratory of Food Microbiology.

Fachliche Lernziele

Die Studierenden
- setzen im Studium erworbenes und im Rahmen der Lehrveranstaltung neu erarbeitetes Wissen ein, um zu beurteilen, welche Mikroorganismen in welchen Lebensmitteln relevant sind.
- können entscheiden, welche Verfahren zum Nachweis welcher Mikroorganismen geeignet sind.

Überfachliche Lernziele

Die Studierenden
- evaluieren und bewerten ihre Ergebnisse vor dem Hintergrund der verwendeten Methoden.
- dokumentieren ihre Tätigkeiten in einem Laborjournal in übersichtlicher Form und diskutieren die erhaltenen Ergebnisse kritisch.
- präsentieren die erhaltenen in mündlicher Form verständlich und nachvollziehbar.

Teaching of basic experimental knowledge for detection and identification of foodborne pathogens by applying state-of-the-art techniques as well as modern molecular techniques for the rapid identification of relevant foodborne pathogens.

Lecture notes

Handouts were provided at the start of the course

Literature

- Krämer: "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
- Süssmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)

Prerequisites

Important information!

During the course we will work with the food-borne pathogen Listeria monocytogenes. Listeria monocytogenes represents a particular threat to pregnant women. Due to biosafety reasons participation is not allowed in case of pregnancy.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered

Social Competencies
Communication assessed

Personal Competencies
Critical Thinking fostered

Microbial Community Genomics

W 6 credits 7P S. Sunagawa

Number of participants limited to 10.

Prerequisites: Participants should bring their own laptop computer. Basic knowledge in [R], Python and/or UNIX is required.

The enrolment is done by the D-BIOL study administration.

Abstract
We provide training in the use of computational methods to address molecular, genetic, ecological and/or evolutionary questions by analyzing DNA sequencing data from microbial communities. The course includes lectures, tutorials, and the development of a research project at the intersection between microbiology and bioinformatics.

Objective

Students will learn concepts and methods for analyzing complex 'omics' datasets and applying them in individual projects. To facilitate learning, the course includes lectures on functional genomics, metagenomics and microbiology, along with practical sessions on scientific programming to analyze and visualize biological data. Additionally, students will learn how to plan, execute, report on, and present a scientific project.

Prerequisites

Participants should bring their own laptop computer. Basic knowledge in [R], Python and/or UNIX is required.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence assessed

Personal Competencies
Adaptability and Flexibility fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Bioactive Natural Products from Bacteria

W 6 credits 7P J. Piel

Number of participants limited to 8.

The enrolment is done by the D-BIOL study administration.

Abstract
Lab course. In small groups projects of relevance to current research questions in the field of bacterial natural product biosynthesis are addressed.

Objective
Introduction to relevant subjects of the secondary metabolism of bacteria. Training in practical work in a research laboratory. Scientific writing in form of a research report.

Content
Research project on bacteria that produce bioactive natural products (e.g., Streptomycetes, Cyanobacteria, uncultivated bacteria). The techniques used will depend on the project, e.g. PCR, cloning, natural product analysis, precursor feeding studies, enzyme expression and analysis.

Lecture notes
none.
Introduction to Ecology

Number of participants limited to 15. The enrolment is done by the D-BIOL study administration.

ATTENTION: Students of the biology teaching diploma, please contact Dr. O. Martin until 01.08.2024.

Abstract


Objective

Studierende vertiefen ihr Wissen zu ökologischen Themen konkret anhand von:

- Vorlesungen zu Grundlagen der Ökologie
- Planen und Durchführen von Experimenten (z.B. Verhaltensökologie mit Insekten)
- Literaturdiskussionen
- Einblicke in aktuelle ökologische Forschungsarbeiten im Raum Zürich (z.B. Gastvorträge, Laborbesuche)
- Besprechung der Möglichkeiten zum Einsatz von Ökologie im theoretischen und praktischen Unterricht

Content

- Einleitung: evolutionäre Hintergrund der Ökologie / Ökologie in Forschung und Praxis
- Umweltbedingungen und Ressourcen: Abiotische Umweltbedingungen & Verfügbarkeit von Ressourcen / Klima & Biome der Erde
- Individuen & Populationen: Geburt, Tod & Wanderungen / Interessenkreis Konkurrenz / Prädation, Weidegang & Parasiten / Molekular & evolutionäre Ökologie
- Lebensgemeinschaften und Ökosysteme: Von Populationen zu Lebensgemeinschaften / Muster des Artenreichtums / Energie- & Stofffluss durch Ökosysteme
- Angewandte Aspekte der Ökologie: Globale biogeochemische Kreisläufe & ihre Veränderung durch den Menschen / Naturschutzbiologie / Ökologie des Menschen: Bevölkerungswachstum, Krankheiten & Nahrungsernährung

Lecture notes

Kursunterlagen werden via Moodle verfügbar sein.

Literature


Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Communication

Social Competencies

- Cooperation and Teamwork

Personal Competencies

- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Polymers Physics Methods for Unstructured Biomolecules

Enrollment limited to 12 students. Enrollment is done by the D-BIOL study administration.

Abstract

Establishing a link between known phenomena, concepts and spectroscopic techniques in polymer physics on the one hand and the study of unstructured biological macromolecules on the other. Attention is paid to the relationship between molecular interactions in biopolymers and their tendency to form molecular condensates, such as membraneless organelles.

Objective

Expansion of competences for the experimental and analytical treatment and structural characterization of partially and completely unstructured biomacromolecules as well as their interactions and self-organization.

Content

- Part I: Molecular interactions, concepts of polymer physics, spectroscopic methods; Part II: Polymer types in biology - proteins, DNA/RNA, polysaccharides, lipids; Part III: Molecular modeling and determination of conformational ensembles.

Lecture notes

Script for part I of the course in HS2024; slides for all three parts.

Literature


Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Decision-making
- Problem-solving

Block Courses in 4th Quarter of the Semester

From 28.11.2024 to 20.12.2024

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0361-00L</td>
<td>Biology of Bryophytes and Ferns</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>R. Holderegger, A. L. Bergamini</td>
</tr>
<tr>
<td></td>
<td>Number of participants limited to 16.</td>
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<tr>
<td></td>
<td>The enrolment is done by the D-BIOL study administration.</td>
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</tbody>
</table>

Abstract

Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes; field trip.

Ferns: basic knowledge on the life cycle, morphology, evolution and ecology of ferns; identification of Swiss ferns; field trips.

Objective

Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes.

Ferns: basic knowledge on the life cycle, morphology, evolution and ecology of ferns; identification of Swiss ferns.

Content

Bryophytes: Systematics and morphology of hornworts, liverworts and mosses and additional topics such as ecology, biogeography, diversity and endangerment of bryophytes; one full-day field trip.

Ferns: Life cycle and morphology; evolutionary groups of ferns including horsetails and lycopods; mating systems, phylogeny and evolutionary processes; ecology; full-day and half-day field trips.
This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different injuries. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer.

Objective:
The students will obtain an overview about the diversity of current RNA-research at all levels from structural biology to systems biology using mainly model systems like S. cerevisiae (yeast), mammalian cells. The goal is to acquire the techniques to image bacteria by electron cryotomography, resolving their structure in a native state, in 3D, and to understand the importance of motor proteins in cellular motility.

Method-specific Competencies:
- Analytical Competencies fostered
- Communication fostered
- Cooperation and Teamwork fostered
- Creative Thinking fostered

Personal Competencies:
- Adaptability and Flexibility fostered
- Leadership and Responsibility fostered
- Self-direction and Self-management fostered

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 289 of 2667
Content

Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. Their function is essential for intracellular transport, muscle contraction and other cellular motility as well as cell division. Motor proteins have been major targets of biophysical studies. There exist questions from atomic to tissue levels – how ATP hydrolysis causes conformational change of motor proteins; how their motion is regulated by calcium, phosphorylation and other factors; how motions of multiple motor proteins are coordinated to generate cellular motility. Structural biology has been playing central roles to answer these questions. X-ray crystallography and single particle cryo-EM address structural analysis at atomic resolution and try to reveal molecular mechanism of conformational change. Cryo-electron tomography analyze localization and 3D structure of motor proteins in the cell to explain how motions of molecular motors happen in the context of cellular environment and are integrated into cellular motion.

In this course, we study dynesins in cilia. Cilia are force-generating organelles, made by microtubules and thousands of dyneins. Dynein hydrolyzes ATP and undergoes conformational change, generating linear motion with respect to the microtubule. As a whole system, cilia integrate motions of these dyneins and orchestrate beating motion. To explain ciliary motion at molecular level, we need to know dynein conformational change in the cellular context. Cryo-electron tomography is recently developed technique to study molecular structures in vivo and therefore a suitable method to study dynein in cilia. Recently spatial resolution of these cryo-EM techniques was dramatically improved, driven by development of new types of detectors and electron optics. The participants of this course will learn a program to analyze cryo-electron tomography and single particle cryo-EM data, acquired by highest-end electron microscopes and detectors in ETH and other places, and reconstruct 3D structure (tomogram) of cilia from various organisms (from green algae to human). They will further learn a program to study molecular structures from these tomograms (called subtomogram averaging) and apply it to reconstruct high-resolution 3D structure of dyneines, microtubules and regulatory proteins. This practical course is therefore mainly computational, but we will also provide students a chance of cilia preparation from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH.

Lecture notes

Scripts will be distributed during the course.

Literature

An overview is given in the following review articles. Further literature will be indicated during the course.

Block Courses in the 1st Half of the Semester

From 17.09.2024 to 01.11.2024

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

This course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with rivers, groundwater and lakes. This course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) as well as excursions.

Objective

During this course you will get an overview of the world's typical continental aquatic ecosystems. After this course you will be able to understand how aquatic organisms have adapted to their habitat, and how the interactions (e.g. food web) between organisms work. During the experimental part of this course you will learn the principles of doing research to observe interrelations in aquatic ecosystems. You will measure and interpret biological and physical data (e.g. during experiments, field work) and present the collected knowledge scientifically.

After this course you will know the most important aquatic species groups (macroinvertebrates, microinvertebrates and freshwater algae) in Switzerland and the most important identification traits.

Content

The course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) and field excursions.

Lecture

The lecture part covers ecology and evolution of aquatic organisms in lentic and lotic waters. Topics include: Adaptations, distribution patterns, biotic interactions, and conceptual paradigms in freshwater ecosystems; important aspects regarding ecosystem metabolism and habitat properties of freshwaters; applied case studies and experiments testing ecological and evolutionary processes in freshwaters.

Practical part:

The practical part includes an excursion to Greifensee and a 3-day-excursion to the river Glatt in Niederuzwil, where you independently perform small research projects. Additionally, you will perform in small groups an independent experiment in a research group at Eawag.

The taxonomic part will cover macroinvertebrates (e.g. Crustacean, aquatic insects), microinvertebrates and algae. The goal is to get to know the most common aquatic taxa in Switzerland, to identify them with commonly used identification literature, and to get an idea how these organisms are used in research and practice. (Language: German, translation of the most important things during the course possible)

Lecture notes

Course notes and power point presentations provided during the course.

Prerequisites / notice

The maximal participating number of biology students is 16.

The course includes a field trip to Greifensee (21.09.2023) and a 3-day-excursion to the river Glatt in Niederuzwil from 27.09. to 29.09.2023.
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Negotiation: assessed
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

529-0810-01L Laboratory Course Organic Chemistry II

- W 12 credits 14P C. Thilgen

Abstract
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Objective
- Learn to plan and carry out challenging multistep syntheses making use of modern methods;
- Reach a deeper understanding of organic reactions through experimental work;
- Develop an organic-synthetic research project;
- Take accurate notes, write a publication style report, and present the obtained results in a seminar.

Content
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Lecture notes
No course notes.

Literature
No set textbooks. Literature will be indicated or provided by the supervising tutors.

Prerequisites
- Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00).
- The number of participants per course is limited to 4.

Block Courses in the 2nd Half of the Semester
From 05.11.2024 to 20.12.2024

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

Data: 02.07.2024 12:39 Autumn Semester 2024
Literature
No set textbooks. Literature will be indicated or provided by the supervising tutors.

Prerequisites / notice
Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Block Courses during the Semester Break

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1709-00L</td>
<td>Genomic and Genetic Methods in Cell and Developmental Biology</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>A. Wutz, M. Kopf, T. Schroeder</td>
</tr>
</tbody>
</table>

Abstract
This course aims to provide students with a comprehensive overview of mammalian developmental biology and stem cell systems both on the theoretical as well as the experimental level. Centering the course on genetic and genomic methods engages the students in contemporary research and prepares for future studies in the course of semester and master projects.

Objective
- Understanding mammalian development
- Introduction to stem cells systems
- Working with cultured cells
- Translational aspects of mammalian cell biology

Content
The course will consist of a series of lectures, assay assignments, project development and discussion workshops, and 2 and a half week of lab work with different mammalian cell systems embedded in real life research projects. At the end of the course students will take an exam consisting of questions on the topic of the lectures and workshops. It is expected that students will be able to apply the knowledge to concrete problems.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

Science in Perspective

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BIOL

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Biology Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Dr</th>
<th>Suitable for doctorate</th>
<th>W</th>
<th>Eligible for credits</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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</table>
### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Biology Teaching Diploma

Detailed information on the programme at: www.didaktischeausbildung.ethz.ch

Educational Science

Course offerings in the category Educational Science are listed under “Programme: Educational Science for Teaching Diploma and TC”.

Please note that the course unit number will change from autumn semester 2024 onwards. This change has no influence on the course units and achievements completed so far and will be recognized for the respective degree.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>871-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects ■ W</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<tr>
<td></td>
<td>- Get information about recent literature on learning and instruction</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>871-0242-07L</td>
<td>Human Intelligence ■ W</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>E. Stern</td>
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<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td>Abstract</td>
<td>The focus will be on the book “Intelligenz: Grosse Unterschiede und ihre Folgen” by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<tr>
<td>Objective</td>
<td>- Understanding of research methods used in the empirical human sciences</td>
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<td>- Getting to know intelligence tests</td>
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<tr>
<td></td>
<td>- Understanding findings relevant for education</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0229-00L</td>
<td>Using Outdoor Education ■ W</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>R. Schumacher, P. Faller</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.</td>
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<tr>
<td>Abstract</td>
<td>In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.</td>
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<tr>
<td>Content</td>
<td>Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:</td>
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<tr>
<td></td>
<td>- Dendrochronology: What annual rings tell</td>
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<td></td>
<td>- Photosynthesis/Climate change: The tracks in the forest</td>
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<td></td>
<td>- Forest Soil: The soil in the focus of the climate</td>
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Subject Didactics in Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0961-00L</td>
<td>Mentored Work Subject Didactics Biology A ■ O</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>P. Faller, H. Stocker</td>
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<tr>
<td></td>
<td>The Subject Didactics as well as possible branch-specific requirements must be fulfilled prior to commencing the mentored paper.</td>
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<tr>
<td>Abstract</td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures. Under supervision, they compile tuition materials enabling effective learning and/or analyse and reflect on certain topics from a subject-based and pedagogical perspective.</td>
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<tr>
<td>Objective</td>
<td>The objectives for the students are</td>
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</tr>
<tr>
<td>Content</td>
<td>Thematische Schwerpunkte Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Beginn nach Absprache jederzeit möglich, jedoch erst nach Abschluss der Fachdidaktik I und II und nach Erfüllung allfälliger fachwissenschaftlicher Auflagen.</td>
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<tr>
<td></td>
<td>Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0962-00L</td>
<td>Mentored Work Subject Didactics Biology B ■ O</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>P. Faller, H. Stocker</td>
</tr>
<tr>
<td></td>
<td>The Subject Didactics as well as possible branch-specific</td>
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Data: 02.07.2024 12:39
Autumn Semester 2024
**Lecturers**

ECTS

**Introductory Internship Biology**

<table>
<thead>
<tr>
<th>Content</th>
<th>Objective</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Themenbezogene Schwerpunkte</td>
<td>- Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.</td>
<td>Beginn nach Absprache jederzeit möglich, jedoch erst nach Abschluss der Fachdidaktik I und II und nach Erfüllung allfälliger fachwissenschaftlicher Auflagen.</td>
</tr>
<tr>
<td>Literatur</td>
<td>- Eine kurze Anleitung zur mentorisierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.</td>
<td></td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td><strong>Title</strong></td>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>551-0971-00L</td>
<td>Subject Didactics Biology I</td>
<td></td>
</tr>
<tr>
<td>551-0968-00L</td>
<td>Teaching Internship Biology</td>
<td></td>
</tr>
</tbody>
</table>

| Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements. | |

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0968-00L</td>
<td>Introductory Internship Biology</td>
<td>O</td>
<td>3 credits</td>
<td>6P</td>
<td>P. Faller</td>
</tr>
<tr>
<td>551-0966-00L</td>
<td>Teaching Internship Biology</td>
<td>O</td>
<td>8 credits</td>
<td>17P</td>
<td>P. Faller</td>
</tr>
</tbody>
</table>
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.
- They plan and conduct laboratory experiments in schools.

Examination Lesson I Biology

In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Objective


Content


Lecture notes

Nach Abschluss der übrigen Ausbildung.

Prerequisites / notice

Findet in der Regel am Schluss der Ausbildung, vor Ablegung der Prüfungslektionen statt.

Professional Exercises in Biology

Students conduct a series of "classical" biological school experiments and therefore gain practice and experience in this area.

Objective

- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Abstract


Lecture notes

Nach Abschluss der übrigen Ausbildung.

Prerequisites / notice

Findet in der Regel am Schluss der Ausbildung, vor Ablegung der Prüfungslektionen statt.

Innovative Biology Teaching at High School

An adequate treatment of current topics of biological research in high schools is a central challenge for future teachers. In this module, students either develop learning materials that aim to prepare new content in a way that is suitable for pupils, or they focus on testing activating forms of learning in real lessons.

Number  Title  Type  ECTS  Hours  Lecturers
551-0976-00L  Innovative Biology Teaching at High School  O  4 credits  9A  H. Stocker, Y. Barral, P. Faller
Objective

Students learn to
- engage with current biological research and its relevance to society
- carefully select content for high school
- make meaningful and correct didactic reductions
- compose activating and motivating learning arrangements
- put prepared lessons into practice
- reflect on their role as a teacher.

Content

Students can choose from three options:

Seminar paper:
Writing a textbook chapter on a current topic in biological research (focus on content).

Innovative lesson:
Planning and implementation of biology lessons with special consideration of activating forms of learning (focus on didactics).

The results will be presented and discussed in a seminar.

Prerequisites / notice

The module "Innovative Biology Teaching at High School" is an integral part of the Specialized Biology Course with an Educational Focus. Before taking this module, at least one of the two lectures should have been completed.

The Specialized Biology Course with an Educational Focus can be acknowledged, in agreement with the advisor of the respective elective major, as one of the two obligatory research projects. In such a case, additional 3 CP must be obtained in another course.

Competencies

Subject-specific Competencies
Concepts and Theories
Method-specific Competencies
Media and Digital Technologies
Problem-solving
Project Management
Social Competencies
Communication
Cooperation and Teamwork
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Personal Competencies
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

551-0973-00L Specialized Biology Course with an Educational Focus: Evolution

Abstract

Specialist aspects of biology with a focus on evolution are covered from the angle of imparting these to pupils, their historical development, and their significance for the subject, the individual and society.

Objective

After successful completion of the module, students should be able
- to retrieve in-depth knowledge of biology with a special focus on evolution and to impart this to others.
- to analyse controversial topics and to give factual explanations for these.
- to prepare teaching units suitably tailored to the recipients, with complex learning matter on a high professional level.

Content

Selected biological topics, with a special focus on evolution, are dealt with under consideration of the special needs of persons involved in teaching.

The module comprises lectures, a book club, and a project assignment.

Lecture notes
Teaching materials are available online on Moodle.

Literature
Literature and references are posted online on Moodle.

Prerequisites / notice

The Specialized Biology Course with an Educational Focus consists of three modules (4 CP each). In the fall semester, the focus of the lecture is on evolution. The lecture of the spring semester deals with biological concepts. The sequence of assignment is free. In addition, the module "Innovative Biology Teaching at High School" has to be completed.

Performance is assessed during the course of the entire module. Active participation in the course is required.

The Specialized Biology Course with an Educational Focus can be acknowledged, in agreement with the advisor of the respective elective major, as one of the two obligatory research projects. In such a case, additional 3 CP must be obtained in another course.

In case of overbooking of the course, students enrolled in the Teaching Diploma in Biology will have priority.

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Social Competencies
Communication
Personal Competencies
Creative Thinking

See Compulsory Elective Courses Teaching Diploma

Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

Number Title Type ECTS Hours Lecturers
701-0015-00L Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement W 2 credits 1S B. Vienni Baptista, C. E. Pohl, M. Stauffacher

Abstract

This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.
Objective

Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, or how to secure broader impact of research. They learn to critically reflect their own research project in its societal context and on their role as scientists.

Content

The seminar covers the following topics:
1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

Literature

Literature will be made available to the participants.
The following open access article builds a core element of the course:

Further, this collection of tools will be used:
https://naturalsciences.ch/topics/co-producing_knowledge
https://www.shapeidtoolkit.eu

Prerequisites / notice

Participation in the course requires participants to be working on their own research project.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
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<td>Problem-solving</td>
<td>Cooperation and Teamwork</td>
<td>Sensitivity to Diversity</td>
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<td>Self-awareness and Self-reflection</td>
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</table>

701-1651-00L Environmental Governance W 6 credits 3G E. Lieberherr

Abstract

The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

Objective

To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

Content

To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

To analyze the evolution as well as the key elements of environmental governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of "environmental governance" and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Furthermore, we encourage the development of soft skills by engaging students in activities such as moderating discussions in class, presenting own proposals, giving regular peer feedback, as well as critically reflecting on various relevant publications in the environmental governance domain.

Lecture notes

Lecture slides, a script and additional course material will be provided on Moodle.

A detailed course schedule will be made available at the beginning of the semester.

During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)
Concepts and Theories

Using Outdoor Education

Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.

Abstract
In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

Objective
Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Content
Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:
- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

Human Physiology I

Abstract
Dieser Kurs vermittelt die Grundlagen der Physiologie und Anatomie des menschlichen Körpers.
Der Schwerpunkt dieses Kurses liegt auf dem Verständnis der physiologischen Mechanismen des menschlichen Körpers. Im Mittelpunkt steht dabei der gesunde Mensch, ergänzt um Beispiele für klinisch wichtige Funktionsstörungen/ Krankheiten. Im Sinne einer integrativen Betrachtungsweise wird bezüglich Funktion jeweils der Bogen von den molekularen Mechanismen bis zum komplexen Zusammenspiel der Organe im Gesamtorganismus gespannt. Die Anatomie wird dort speziell besprochen, wo sie für das Verständnis der Funktion notwendig oder hilfreich ist.

Kurs umfasst das Herbst- (Teil I) und das Frühjahrssemester (Teil II). Im Teil I werden Kern-Konzepte der Physiologie vermittelt, also die grundlegenden Mechanismen, die für das Verständnis aller physiologischen Prozesse notwendig sind. Die Studierenden werden dazu befähigt, diese allgemeinen Prinzipien auf die Funktionen aller Organsysteme und deren Zusammenspiel anzuwenden. Im Teil II werden zudem die allgemeinen Aspekte des Nervensystems und des endokrinen Systems eingeführt, da alle Organfunktionen letztlich unter nervaler und endokriner Kontrolle stehen.

**Content**

Humanphysiologie I (HS)

- «Kern-Konzepte» in der Physiologie
  1. Struktur und Funktion
  2. Energietransfer, -speicherung und -nutzung
  3. Informationsfluss, -speicherung und -nutzung
  4. Homöostase
  5. Evolution
- Allgemeine Endokrinologie und endokrines System
- Allgemeine Neurophysiologie und Neuroanatomie
- Die chemischen Sinne, Geschmack und Geruch
- Ernährung und Verdauung
- Leber und Stoffwechsel
- Energiehomöostase
- Flüssigkeitshomöostase und Niere
- Reproduktion, Entwicklung und Altern

Humanphysiologie II (FS)

- Sinnesphysiologie
- Muskelsphysiologie
- Neuronale Kontrolle von Haltung und Bewegung
- Höhere zentralnervöse Hirnfunktionen
- Atmung und Lunge
- Herz und Kreislauf
- Blut
- Immunologie
- Thermoregulation/Fieber
- Stress

**Lecture notes**

Online-Material wird im Laufe des Kurses zur Verfügung gestellt.

**Literature**

Wird im Kurs bekannt gegeben.

**Competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Analytical Competencies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-4001-00L</td>
<td>Microbiology</td>
<td>E- 2 credits 2V</td>
<td>M. Schuppner, M. La Fortezza, M. Pilhofer, S. Robinson</td>
</tr>
<tr>
<td>Abstract</td>
<td>Some parts of the lecture will be taught in English. Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Teaching of basic knowledge in microbiology.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Der Schwerpunkt liegt auf den Themen: Bakterielle Zellbiologie, Molekulare Genetik, Wachstumsphysiologie, Biochemische Diversität, Phylogenie und Taxonomie, Prokaryotische Vielfalt, Interaktion zwischen Menschen und Mikroorganismen sowie Biotechnologie.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Wird von den jeweiligen Dozenten ausgegeben.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0127-01L</td>
<td>Plants and Fungi</td>
<td>E- 4 credits 3G</td>
<td>S. C. Zeeman, M. Künzler, O. Y. Martin</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture conveys the fundamental concepts underlying multicellularity with an emphasis on the molecular basis of multicellular biological systems and their functional integration into coherent wholes. The structural and functional specialization in multicellular organisms will be discussed by highlighting common and specific functions in fungi and plant.s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>1. Students can describe advantages and challenges associated with being multicellular and outline independent solutions that organisms have developed to cope with the challenges of complex multicellularity. 2. Students can explain how the internal and external structures of fungi and plants function to support survival, growth, behavior, and reproduction. 3. Students can explain the basic pathways and mechanisms of cellular communication regulating cellular behavior (cell adhesion, metabolism, proliferation, reproduction, development). 4. Students can describe how a single cell develops from one cell into many, each with different specialized functions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>The lecture introduces the structural and functional specialization in fungi and plants. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi and plants have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Some lectures are held in English.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

**Method-specific Competencies**
- Analytical Competencies: assessed
- Cooperation and Teamwork: fostered

**Social Competencies**
- Creative Thinking: fostered
- Critical Thinking: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**Personal Competencies**
- Analytical Competencies: fostered
- Social Competencies: Communication fostered
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### Introduction to Ecology

**Number of participants limited to 15.**
**The enrolment is done by the D-BIOL study administration.**

**ATTENTION:** Students of the biology teaching diploma, please contact Dr. O. Martin until 01.08.2024.

**Abstract**

**Objective**
Studierende vertiefen ihr Wissen zu ökologischen Themen konkret anhand von:
- Vorlesungen zu Grundlagen der Ökologie
- Planen und Durchführen von Experimenten (z.B. Verhaltensökologie mit Insekten)
- Literaturdiskussionen
- Einblicke in aktuelle ökologische Forschungsarbeiten im Raum Zürich (z.B. Gastvorträge, Laborbesuche)
- Besprechung der Möglichkeiten zum Einsatz von Ökologie im theoretischen und praktischen Unterricht
- Exkursionen & Führungen

**Content**
- Einleitung: evolutionäre Hintergrund der Ökologie / Ökologie in Forschung und Praxis
- Umweltbedingungen & Ressourcen: Abiotische Umweltbedingungen & Verfügbarkeit von Ressourcen / Klima & Biome der Erde
- Individuen & Populationen: Geburt, Tod & Wanderungen / Interspezifische Konkurrenz / Prätation, Weidegang & Parasiten / Molekulare & evolutionäre Ökologie
- Lebensgemeinschaften und Ökosysteme: Von Populationen zu Lebensgemeinschaften / Muster des Artenreichtums / Energie- & Stofffluss durch Ökosysteme
- Angewandte Aspekte der Ökologie: Globale biogeochemische Kreisläufe & ihre Veränderung durch den Menschen / Naturschutzbiologie / Ökologie des Menschen: Bevölkerungswachstum, Krankheiten & Nahrungsversorgung

**Lecture notes**
Kursunterlagen werden via Moodle verfügbar sein.

**Literature**

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### Biology Teaching Diploma - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

### Key for Hours

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |
| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Biology Master

Master Studies (Programme Regulations 2023)

Majors

Major in Biochemistry

Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>U. Kutay, F. Allain, T. Kleele, I. Zemp</td>
</tr>
</tbody>
</table>

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Compulsory Master Course

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-1303-00L</td>
<td>Current Research Topics in Cellular Biochemistry</td>
<td>O</td>
<td>4</td>
<td>2S</td>
<td>T. Kleele, V. Korkhov, G. Neurohr, V. Panse, M. Peter, A. E. Smith, F. van Drogen</td>
</tr>
</tbody>
</table>

Abstract
During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

Objective
Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to evaluate, critically discuss and write about scientific articles in the research area of cellular biochemistry, and they will identify open testable research questions.

Content
Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with frontal presentations. Guided by a faculty expert, students develop domain knowledge of the research area associated with a primary paper, and alternate as discussion leaders to present the research topic. By the end of the semester, students will formulate their ideas about open testable research questions that extend from the published work.

Literature
The literature will be provided during the course.

Prerequisites / notice
The course will be taught in English.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytic.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.
Basics: assessed 5 credits

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems biology, computational approaches to address contemporary biological problems related to metabolism. The course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Lecturers: University lecturers

Abstract

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective

This course focuses on the concepts of classical and modern genetics and genomics.

Content

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes

Scripts and additional material will be provided during the semester.

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Problem-solving

Social Competencies

Communication

Cooperation and Teamwork

Self-presentation and Social Influence

Personal Competencies

Creative Thinking

Critical Thinking

Self-awareness and Self-reflection

Self-direction and Self-management

Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Literature


- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

- Creighton, T.E., Proteins, Freeman, (1993)


Current topics: References will be given during the lectures.

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>U. Sauer, N. Zamboni</td>
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</table>

Abstract

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective

Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content

The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes

Script and original publications will be supplied during the course.

Prerequisites / notice

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

636-0007-00L | Computational Systems Biology | W | 6 | 3V+2U | J. Stelling |

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Content

Biological systems have witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes

http://www.csb.ethz.ch/education/lectures.html


401-0649-00L | Applied Statistical Regression | W | 5 | 2V+1U | M. Dettling |

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 303 of 2667
Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

529-0041-00L Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

Abstract
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Lecture notes
Lecture notes will be made available online.

Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

Prerequisites / notice
Exercises are an integral part of the lecture.
Prerequisites: 529-0051-00 "Analytische Chemie I (3. Semester)"; 529-0058-00 "Analytische Chemie II (4. Semester)" (or equivalent)
### 636-0107-00L RNA Biology Lecture Series I: Transcription & Processing & Translation

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<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>4 credits</td>
<td>2V</td>
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<tr>
<td>Objective</td>
<td>W</td>
<td>M. Fussenegger</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation. The students should obtain an understanding of these processes, which are at work during gene expression.</td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Basic knowledge of cell and molecular biology.</td>
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### 551-1407-00L RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

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<tr>
<td>Objective</td>
<td>W</td>
<td>J. Hall, M. Stoffel, further lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases. The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.</td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Basic knowledge of cell and molecular biology.</td>
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</table>

### 227-0939-00L Cell Biophysics

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<td>T. Zambelli</td>
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<td>Objective</td>
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<tr>
<td>Abstract</td>
<td>Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature. Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms. Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy. Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature. By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Does not take place this semester.</td>
<td></td>
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</table>

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Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o'clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!

Literature


As further deepening:


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tr>
<td>Social Competencies</td>
<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td></td>
<td>Project Management</td>
<td>assessed</td>
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</table>

| Communication | fostered |
| Cooperation and Teamwork | fostered |
| Customer Orientation | fostered |
| Leadership and Responsibility | fostered |
| Self-presentation and Social Influence | fostered |
| Sensitivity to Diversity | assessed |
| Negotiation | fostered |

| Personal Competencies | Adaptable and Flexibility | assessed |
|                      | Creative Thinking | assessed |
|                      | Critical Thinking | assessed |
|                      | Integrity and Work Ethics | assessed |
|                      | Self-awareness and Self-reflection | assessed |
|                      | Self-direction and Self-management | assessed |

Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Competencies

| Subject-specific Competencies | Concepts and Theories | assessed |
| Methd-specific Competencies  | Techniques and Technologies | fostered |
| Social Competencies          | Analytical Competencies | assessed |
|                              | Decision-making       | assessed |
|                              | Media and Digital Technologies | fostered |
|                              | Problem-solving       | assessed |
|                              | Project Management    | assessed |

| Communication | fostered |
| Cooperation and Teamwork | fostered |
| Customer Orientation | fostered |
| Leadership and Responsibility | fostered |
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|                      | Integrity and Work Ethics | assessed |
|                      | Self-awareness and Self-reflection | assessed |
|                      | Self-direction and Self-management | assessed |

551-0357-00L

Cellular Matters: Properties, Functions and Applications of Biomolecular Condensates

The number of participants is limited to 30 and will only take place with a minimum of 6 participants.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Abstract

This Master level course delves into the emerging field of biomolecular condensates - membrane-less organelles in cells. Using interdisciplinary concepts from biology, chemistry, biophysics, and soft matter, we will explore the biological properties of these condensates, their functions in health and disease, and their potential as new biomimetic materials for various applications.

551-0357-00L

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Abstract

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Objective

In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similar to emulsions.

This interdisciplinary course encompasses milestone works and cutting-edge research questions in the young field of biomolecular condensates, including their properties, functions, and applications. The course begins with a lecture series that introduces the topic of condensates to an interdisciplinary audience and provides a theoretical foundation for understanding current research questions in the field. The lectures provide a base for student presentations of recent publications in the field, and for research seminars given by course lecturers, who are all active researchers with diverse expertise. Through this exciting interdisciplinary understanding of biomolecular condensates, bridging biology, chemistry, biophysics, and soft matter.

Students will not only learn how to critically read and evaluate scientific literature but will also gain valuable experience in giving scientific presentations to an interdisciplinary audience. Each presentation will require an introduction, critical analysis of the results, and a discussion of their significance, allowing student to substantiate their statements with a critical mindset that considers the pros and cons of chosen approaches and methods, as well as any limitations or possible follow-up experiments. This process will enable student to ask relevant queries and actively participate in class discussions, further enhancing their scientific skills.

In preparing the presentations, the students will have the unique opportunity to interact closely with each other and with the lecturers, who are all internationally well-established experts, and receive guidance in select a topic for the final presentation and supporting literature.

Content

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and requires a multi-disciplinary approach that leverages and cross-fertilizes biology, physical chemistry, biophysics, and soft matter. This course will explore the properties, functions and potential applications of biomolecular condensates, including their role in neurodegenerative diseases such as Alzheimer's and Parkinson's, as well as their use as smart biomimetic materials.

This course is divided into two parts. The fist part will introduce the basic concepts essential to the study of biomolecular condensates and phase separation. Topics include: fundamental units and scales in soft matter, phase transitions in biology, biopolymers and molecular self-assembly, introduction to active matter. This will establish a foundation for the second part, which will explore milestone works and current research in the field of biomolecular condensates. Each lecture of this second part will consist of:

1) a short literature seminar, where student groups will present and discuss a milestone paper assigned in advance and
2) a research seminar, where one of the course lecturers will present their own state-of-the-art research in the field, building upon the milestone literature.

At the beginning of the course, student groups will be formed and assigned to the milestone literature. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Lecture notes

Lecture slides and some scripts will be provided.

Literature

No compulsory textbooks. Literature will be provided during the course

Competencies

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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
<td>Self-direction and Self-management</td>
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</table>

529-0733-02L Chemical Biology and Synthetic Biochemistry

W 6 credits 3G K. Lang, M. Fottner

Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context. B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.

Advanced genetic code expansion methods (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing)

directed evolution and protein engineering

chemical biology of ubiquitin and targeted protein degradation

A script will not be handed out. Handouts to the lecture will be provided through moodle.

Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.
Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Problem-solving

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Problem-solving

Social Competencies
Communication
Cooperation and Teamwork
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Leadership and Responsibility
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Sensitivity to Diversity
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Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Elective Concept Courses

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<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function. D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
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Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAs, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

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<tr>
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<td>551-0309-00L</td>
<td>Concepts in Modern Genetics Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIC348 at UZH. Please mind the ETH enrolment deadlines for UZH students: <a href="https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html">https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html</a></td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, A. Hajnal, O. Voinnet, University lecturers</td>
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</table>

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Competencies

Concepts and Theories
Techniques and Technologies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Communication
Cooperation and Teamwork
Self-presentation and Social Influence

Creative Thinking
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

Microbiology (Part I)

Abstract
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes
Updated handouts will be provided during the class.
### Immunology I

**W 3 credits 2V**  
M. Kopf, A. Oxenius

**Abstract**  
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**  
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**  
- Introduction and historical background  
- Innate and adaptive immunity, Cells and organs of the immune system  
- B cells and antibodies  
- Generation of diversity  
- Antigen presentation and Major Histoincompatibility (MHC) antigens  
- Thymus and T cell selection  
- Autoimmunity  
- Cytotoxic T cells and NK cells  
- Th1 and Th2 cells, regulatory T cells  
- Allergies  
- Hypersensitivities  
- Vaccines, immune-therapeutic interventions

**Lecture notes**  
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

**Literature**  
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Prerequisites / notice**  
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

**Competencies**  
- Subject-specific Competencies  
  - Concepts and Theories  
  - Techniques and Technologies
- Method-specific Competencies  
  - Analytical Competencies  
  - Decision-making
- Social Competencies  
  - Communication
- Personal Competencies  
  - Adaptability and Flexibility  
  - Creative Thinking  
  - Critical Thinking  
  - Self-direction and Self-management

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### Nucleic Acids and Carbohydrates

**W 6 credits 3G**  
K. Lang, M. Frei, P. A. Kast, H. Wennemers

**Abstract**  
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Objective**  
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Content**  
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Lecture notes**  
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

**Literature**  
Mainly based on original literature, a detailed list will be distributed during the lecture

**Competencies**  
- Subject-specific Competencies  
  - Concepts and Theories  
  - Techniques and Technologies
- Method-specific Competencies  
  - Analytical Competencies  
  - Problem-solving
- Social Competencies  
  - Communication
- Personal Competencies  
  - Self-awareness and Self-reflection  
  - Self-direction and Self-management

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### Recommended Master Courses

**Number**  
**551-0317-00L**  
**551-0317-00L**  
**529-0731-00L**  
**529-0732-00**

**Title**  
- Writing Scientific Reports for MSc Biology
- Nucleic Acids and Carbohydrates
- Proteins and Lipids (spring semester) can be counted for the Bachelor's degree
- Immunology I
- Immunology II

**Type**  
W

**ECTS**  
2

**Hours**  
1G

**Lecturers**  
R. Taylor

**Objective**  
This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

- Students will learn to:  
  - Plan, draft, structure, and edit scientific reports  
  - Produce reader-friendly sentences  
  - Establish a clear and logical flow between sentences and paragraphs  
  - Select formal vocabulary and use it in a generally accurate and correct manner  
  - Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

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**Autumn Semester 2024**  
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The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded.

Prerequisites / notice
Participants should be at a stage in their research where they can already start drafting parts of the report.

### Compulsory Concept Courses

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<tr>
<td>529-0731-00L</td>
<td>Nucleic Acids and Carbohydrates</td>
<td>O</td>
<td>6 credits</td>
<td>3G</td>
<td>K. Lang, M. Frei, P. A. Kast, H. Wennemers</td>
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**Abstract**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Objective**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Content**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Lecture notes**
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

**Literature**
Mainly based on original literature, a detailed list will be distributed during the lecture

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Problem-solving
- **Social Competencies**
  - Communication
- **Personal Competencies**
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

### Elective Compulsory Master Courses

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<tr>
<td>529-0004-01L</td>
<td>Classical Simulation of (Bio)Molecular Systems</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>P. H. Hünenberger, J. Dolenc, S. Riniker</td>
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**Abstract**
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Objective**
Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

**Content**
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Lecture notes**
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

**Literature**
See: www.csms.ethz.ch/education/CSBMS

**Prerequisites / notice**
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Media and Digital Technologies
  - Problem-solving
- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking

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<tr>
<td>529-0233-01L</td>
<td>Organic Synthesis: Methods and Strategies</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>E. M. Carreira</td>
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**Abstract**
The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

**Objective**
Extension and deepening of the knowledge in organic synthesis and the principles of structure and reactivity.

**Content**

**Literature**

**Prerequisites / notice**
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Competencies | Subject-specific Competencies | Concepts and Theories | assessed |
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**529-0243-01L Transition Metal Catalysis: From Mechanisms to Applications**

**Abstract**
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint.

**Objective**
Understanding and critical evaluation of current research in transition metal catalysis. Design of mechanistic experiments to elucidate reaction mechanisms. Synthetic relevance of transition metal catalysis. Students will also learn about writing an original research proposal during a workshop.

**Content**
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint. Synthetic applications of these reactions. Introduction and application of tools for the elucidation of mechanisms. Selected examples of topics include: C-H activation, C-O activation, C-C activation, redox active ligands, main group redox catalysis, bimetallic catalysis.

**Lecture notes**
Lecture slides will be provided online. A Handout summarizing important concepts in organometallic and physical organic chemistry will also be provided. Useful references and handouts will also be provided during the workshop.

**Literature**
Primary literature and review articles will be cited during the course.

The following textbooks can provide useful support for the course:

**Prerequisites / notice**
Required level: Courses in organic and physical chemistry (kinetics in particular) of the first and second year as well as ACI and III Competencies.

**529-0041-00L Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics**

**Abstract**
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

**Objective**
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

**Content**
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

**Lecture notes**
Lecture notes will be made available online.

**Literature**
Information about relevant literature will be available in the lecture & in the lecture notes.

**Prerequisites / notice**
Exercises are an integral part of the lecture.

Prerequisites:
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)
Citations from the original literature relevant to the individual lectures will be assigned weekly.

Fundamental concepts and recent advances for the selective synthesis of complex organic molecules, including natural products, will be covered in Selectivity in Organic Synthesis. This course will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

An advanced course on the synthesis, properties and function of peptides in chemistry and biology, will be covered in Biopolymers. The students should obtain an understanding of these processes, which are at work during gene expression.

This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

Fundamentals of selective organic reactions, including current and historical examples of enantioselectivity, regioselectivity, chemoselectivity. Further aspects include recent developments in catalysis, strategies and tools for selective organic synthesis.

Selectivity in Organic Synthesis

Biological Engineering and Biotechnology

RNA Biology Lecture Series I: Transcription & Processing & Translation

RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

Chemical Biology - Peptides

529-0240-00L

6 credits


Chemical Biology - Peptides

W

4 credits

Biological Engineering and Biotechnology

W

6 credits

Biological Engineering and Biotechnology

W

4 credits

Biological Engineering and Biotechnology

W

4 credits

Biological Engineering and Biotechnology

W

4 credits

Chemical Biology - Peptides

W

3G

H. Wennemers

Biological Engineering and Biotechnology

W

3V

M. Fussenegger

F. Allain, U. Kutay, further lecturers

R. Hall, M. Stoffel, further lecturers

J. Hall, M. Stoffel, further lecturers

J. W. Bode

The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

Micro RNAs; computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; tRNA biology.


Basic knowledge of molecular biology.

Basic knowledge of cell and molecular biology.

Does not take place this semester.

Self-management

Self-reflection

Integrity and Work Ethics

Critical Thinking

Project Management

Adaptability and Flexibility

Creative Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Does not take place this semester.

Nutrition, Health, - An Industrial Perspective. 9. IP

Micro RNAs; computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; tRNA biology.


Basic knowledge of cell and molecular biology.

Basic knowledge of cell and molecular biology.

Does not take place this semester.

Self-direction and Self-management

Self-reflection

Integrity and Work Ethics

Critical Thinking

Project Management

Adaptability and Flexibility

Creative Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Does not take place this semester.

Nutrition, Health, - An Industrial Perspective. 9. IP

Micro RNAs; computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; tRNA biology.


Basic knowledge of cell and molecular biology.
Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective
Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content
• Basics of theory of probability
• Boltzmann’s law
• Entropy maximization and Gibbs free energy minimization
• Ligand-receptor: two-state systems and the MWC model
• Random walks, diffusion, crowding
• Electrostatics for salty solutions
• Elasticity: fibers and membranes
• Molecular motors
• Action potential: Hodgkin-Huxley model
• Photosynthesis and vision
• Gene regulation
• Development: Turing patterns

Theory and corresponding exercises are merged together during the classes.

Lecture notes
No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o’clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!

Literature

As further deepening:

Prerequisites / notice
Participants need a good command of
• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.
The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and requires a multi-disciplinary approach that leverages and cross-fertilizes biology, physical chemistry, biophysics, and soft matter. This course will explore the properties, functions, and applications of biomolecular condensates, including their role in neurodegenerative diseases such as Alzheimer's and Parkinson's, as well as their use as smart biomimetic materials.

This course is divided into two parts. The first part will introduce the basic concepts essential to the study of biomolecular condensates and phase separation. Topics include: fundamental units and scales in soft matter, phase transitions in biology, biopolymers and molecular self-assembly, introduction to active matter. This will establish a foundation for the second part, which will explore milestone works and current research in the field of biomolecular condensates. Each lecture of this second part will consist of:

1) a short literature seminar, where student groups will present and discuss a milestone paper assigned in advance and an active matter seminar, where the course lecturers will present their own state-of-the-art research in the field, building upon the milestone literature.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

This interdisciplinary course encompasses milestone works and cutting-edge research questions in the young field of biomolecular condensates, including their properties, functions, and applications. The course begins with a lecture series that introduces the topic of condensates to an interdisciplinary audience and provides a theoretical foundation for understanding current research questions in the field. The lectures provide a base for student presentations of recent publications in the field, and for research seminars given by course lecturers, who are all active researchers with diverse expertise. Through this exciting interdisciplinary understanding of biomolecular condensates, bridging biology, chemistry, biophysics, and soft matter, we will explore the biological properties of these highly complex fluids that can (meta)stably segregate into membrane-less compartments, similar to emulsions.

In preparing the presentations, the students will have the unique opportunity to interact closely with each other and with the lecturers, who are all internationally well-established experts, and receive guidance in select a topic for the final presentation and supporting literature. Students will not only learn how to critically read and evaluate scientific literature but will also gain valuable experience in giving scientific presentations to an interdisciplinary audience. Each presentation will require an introduction, critical analysis of the results, and a discussion of their significance, allowing student to substantiate their statements with a critical mindset that considers the pros and cons of chosen approaches and methods, as well as any limitations or possible follow-up experiments. This process will enable student to ask relevant question and actively participate in class discussions, further enhancing their scientific skills.

In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similar to emulsions.

### Competencies

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<td>assessed</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<tr>
<td>Creative Thinking</td>
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<tr>
<td>Critical Thinking</td>
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<tr>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
<td>assessed</td>
<td>fostered</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
<td>assessed</td>
<td>fostered</td>
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### Content

**Cellular Matters: Properties, Functions and Applications of Biomolecular Condensates**

**Objective**

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

**Abstract**

This Master level course delves into the emerging field of biomolecular condensates - membrane-less organelles in cells. Using interdisciplinary concepts from biology, chemistry, biophysics, and soft matter, we will explore the biological properties of these condensates, their functions in health and disease, and their potential as new biomimetic materials for various applications.

**In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similar to emulsions.**
**Chemical Biology and Synthetic Biochemistry**

**W** 6 credits 3G  K. Lang, M. Fottner

**Abstract**
Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

**Objective**
A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.

**Content**
- principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries)
- advanced genetic code expansion methods (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing)
- directed evolution and protein engineering
- chemical biology of ubiquitin and targeted protein degradation

**Lecture notes**
A script will not be handed out. Handouts to the lecture will be provided through moodle.

**Literature**
Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

**Prerequisites / notice**
Knowledge provided in the bachelor lectures ‘Nucleic Acids and Carbohydrates’ and ‘Proteins and Lipids’ is assumed for this lecture.

**Elective Concept Courses**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

**Abstract**
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

**Objective**
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

**Lecture notes**
Scripts on the individual topics can be found under [http://www.mol.biol.ethz.ch/teaching](http://www.mol.biol.ethz.ch/teaching).
Current topics: References will be given during the lectures.

551-0319-00L  Cellular Biochemistry (Part I)  W  3 credits  2V  U. Kutay, F. Allain, T. Kleele, I. Zemp

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Competencies
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

551-1299-00L  Bioinformatics  W  6 credits  4G  S. Sunagawa, P. Beltrao, V. Boeva, A. Kahles, C. von Mering, N. Zamboni

Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Competencies
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

Social Competencies
- Communication: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

551-0309-00L  Concepts in Modern Genetics  W  6 credits  4V  Y. Barrai, A. Hajnal, O. Voinnet, University lecturers

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis. This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover assessed

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

2V
Updated handouts will be provided during the class.

Lecturers
W.-D. Hardt, L. Eberl, B. Nguyen,
J. Piel, M. Pilhofer, A. Vagstad

2 credits
W.

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Literature
Current literature references will be provided during the lectures.

Prerequisites /
English
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

>> Recommended Master Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>R. Taylor</td>
</tr>
</tbody>
</table>

Abstract
This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

Objective
Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

Content
The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Prerequisites /
Participants should be at a stage in their research where they can already start drafting parts of the report.

Major in Microbiology and Immunology

Compulsory Concept Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>
| 551-0313-00L | Microbiology (Part I)                        | O    | 3    | 2V    | W.-D. Hardt, L. Eberl, B. Nguyen,
J. Piel, M. Pilhofer, A. Vagstad |

Abstract
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Literature
Current literature references will be provided during the lectures.

Prerequisites /
English
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
</tbody>
</table>

Abstract
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Objective
Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"
This course provides a detailed understanding of U. Suter. Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current ECTS.

Documents of the lectures are available for download at: 

Hours

The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health fostered

Lecturers

A. Oxenius, C. Schneider, E. Slack, R. Spörri, further lecturers

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

Prerequisites / notice

For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Competencies

Subject-specific Competencies

- Concepts and Theories

Techniques and Technologies

- Problem-solving

Method-specific Competencies

- Analytical Competencies

Decision-making

- Project Management fostered

Social Competencies

- Communication fostered

Cooperation and Teamwork fostered

Personal Competencies

- Adaptable and Flexibility fostered

Creative Thinking

- Critical Thinking assessed

Self-direction and Self-management fostered

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Elective Compulsory Master Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tr>
<td>551-0223-00L</td>
<td>Immunology III</td>
<td>W</td>
<td>4 credits</td>
<td>2V</td>
<td>M. Kopr, S. B. Freigang, S. R. Leibundgut, F. Mair, A. Oxenius, C. Schneider, E. Slack, R. Spörri, further lecturers</td>
</tr>
</tbody>
</table>

Abstract

This course provides a detailed understanding of the development of T and B cells, the dynamics of an immune response during acute and chronic infection, immunopathology, modern vaccination strategies. Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective

Obtain a detailed understanding of the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses, recognition of pathogenic microorganisms by the host cells and molecular events thereafter, events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells. Optimization of B cell responses by intelligent design of new vaccines. Content

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections
- Development and selection of CD4 and CD8 T cells
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter
- The dynamics of an immune response during acute and chronic infection
- Immunopathology
- Modern vaccination strategies

Literature

Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice

Immunology I and II recommended but not compulsory

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-0512-00L</td>
<td>Current Topics in Molecular and Cellular Neurobiology</td>
<td>W</td>
<td>2 credits</td>
<td>1S</td>
<td>U. Suter</td>
</tr>
</tbody>
</table>

Abstract

Does not take place this semester.

Objective

The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.

Content

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

Lecture notes

Presentations will be made available after the seminars.

Prerequisites / notice

You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-1117-00L</td>
<td>Cutting Edge Topics: Immunology and Infection Biology</td>
<td>W</td>
<td>2 credits</td>
<td>1S</td>
<td>A. Oxenius, B. Becher, C. Halin Winter, M. Kopf, S. R. Leibundgut, C. MüNZ, L. Tortola, M. van den Broek</td>
</tr>
</tbody>
</table>

Abstract

Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion.

---
Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells,

Student will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on

Often parts of the presented seminars have already been published by the respective speakers and the respective primary research can be

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good

The aim of this course is to confront students with current research topics and with scientific presentation. The course offers the opportunity
to gain in depth knowledge about diverse topics which are often only briefly touched in the concept courses and to engage in discussion
with experts in the field.

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells,

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells,

For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem
areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single
cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

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The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells,

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells,

During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the
structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

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structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

The aim of this course is to confront students with current research topics and with scientific presentation. The course offers the opportunity
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to gain in depth knowledge about diverse topics which are often only briefly touched in the concept courses and to engage in discussion
with experts in the field.

Funding of participants limited to 15. The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Literaturunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

Within the framework of this course, we will work out how the various methods work and what their capabilities/limits are. The problem
areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single
cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Within the framework of this course, we will work out how the various methods work and what their capabilities/limits are. The problem
areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single
cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.
Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with frontal presentations. Guided by a faculty expert, students develop domain knowledge of the research area associated with a primary paper, and alternate as discussion leaders to present the research topic. By the end of the semester, students will formulate their ideas about open testable research questions that extend from the published work.

The literature will be provided during the course.

The course will be taught in English.

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<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Communication</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
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752-4009-00L Molecular Biology of Foodborne Pathogens W 3 credits 2V M. Loessner, A. Harms, M. Schuppler, E. Slack

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophages for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

751-4504-00L Plant Pathology I W 2 credits 2G B. McDonald

Abstract
Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems.

Objective
Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.
Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotophs, disease cycles and pathogen life cycles.

Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytotoxins and mycotoxins. Attack strategies of fungal necrotophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LRAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.


Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.


Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Lecture notes

Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

636-0017-00L Computational Biology  W  6 credits  3G+2A  T. Vaughan, C. Magnus, T. Stadler

Abstract

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

* epidemiology
* pathogen evolution
* macroevolution of species

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

* Yang, Z. 2006. Computational Molecular Evolution.
* Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

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701-1703-00L Evolutionary Medicine for Infectious Diseases

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
The focus is on primary literature, but for some parts the following text books provide good background information:

- Schmid Hempel 2011 Evolutionary Parasitology
- Stearns & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

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752-5500-00L Applied Bioinformatics: Microbiomes

Abstract
Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

Objective
Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

Content
1. Introduction to microbiomes and microbial bioinformatics toolkit. Python, Pandas, Jupyter, GitHub, visualization libraries for Python.
3. Microbial diversity, function, and ecology. Molecular ecology, diversity metrics, ordination methods.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice
No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

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Elective Concept Courses

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<td>M. Loessner, A. Harms</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024   Page 322 of 2667
This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Objective

The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Content

1. History of Food Microbiology
   1.1. Short synopsis of foodborne microorganisms
   1.2. Spoilage of Foods
   1.3. Foodborne Disease
   1.4. Food Preservation
   1.5. VIP's of Food Microbiology
2. Overview of Microorganisms in Foods
   2.1 Origin of foodborne Microorganisms
   2.2. Bacteria
   2.3. Yeasts
   2.4. Molds
3. Microbial Spoilage of Foods
   3.1. Intrinsic and Extrinsic Parameters
   3.2. Meats, Seafoods, Eggs
   3.3. Milk and Milk Products
   3.4. Vegetable and Fruit Products
   3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
   3.6. Drinks and Canned Foods
4. Foodborne Disease
   4.1. Significance and Transmission of Foodborne pathogens
   4.2. Staphylococcus aureus
   4.3. Gram-positive Sporeformers (Bacillus & Clostridium)
   4.4. Listeria monocytogenes
   4.5. Salmonella, Shigella, Escherichia coli
   4.6. Vibrio, Yersinia, Campylobacter
   4.7. Brucella, Mycobacterium
   4.8. Parasites
   4.9. Viruses and Bacteriophages
   4.10. Mycotoxins
   4.11. Bioactive Amines
   4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

Literature

Recommendations will be given in the first lecture.

Competencies

Subject-specific Competencies
   Concepts and Theories assessed
   Techniques and Technologies assessed
Method-specific Competencies
   Analytical Competencies fostered
   Decision-making assessed
   Media and Digital Technologies assessed
   Problem-solving assessed
   Project Management assessed
Social Competencies
   Communication assessed
   Cooperation and Teamwork assessed
   Self-presentation and Social Influence fostered
   Negotiation fostered
Personal Competencies
   Adaptability and Flexibility fostered
   Creative Thinking assessed
   Critical Thinking assessed
   Integrity and Work Ethics fostered
   Self-awareness and Self-reflection fostered
   Self-direction and Self-management fostered

Evolutionary Genetics

Abstract

The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Objective

The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content

Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.
Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossingbreeding, effects on fitness; Fisher's fundamental theorem.
Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation

Molecular Life of Plants

Abstract

The concept course 'Molecular Life of Plants' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Objective

The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content

Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.
Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossingbreeding, effects on fitness; Fisher’s fundamental theorem.
Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation

Literature

The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence.

The new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels.

The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.

The course "Molecular Life of Plants" will cover the following topics:

- Seed structure and physiology, their dormancy and germination.
- Seedling establishment and early development.
- Structure and Function of Meristems, including stem cells.
- Plant organ development (leaves, roots, flowers etc.).
- Plant reproduction.
- The plant vasculature for long-distance transport and other specialized tissues.
- Sensing and responding to the abiotic environment
- Plant-microbe interactions; beneficial friends or pathogenic foes?
- Polyploidy; the benefits, problems and solutions to of multiple genomes.
- Photosynthesis and carbon partitioning.
- Photosynthesis and the evolution of C4 metabolism.
- Starch biosynthesis and degradation.
- Chloroplast development and chlorophyll biosynthesis.
- Senescence mechanisms in plants.
- General principles of RNA silencing
- MicroRNAs: discovery, general principle and modes of action at the cellular and system levels.
- Chromatin-based RNA silencing.
- Antiviral RNA silencing.
- RNA silencing & defense against non-viral pathogens.
- RNA silencing movement and amplification.

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551-0307-00L Molecular and Structural Biology I: Protein Structure and Function
D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

551-0309-00L Concepts in Modern Genetics
Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIOC348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.
551-0319-00L **Cellular Biochemistry (Part I)**

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**Competencies**
- **Method-specific Competencies**: Concepts and Theories
- **Social Competencies**: Communication
- **Personal Competencies**: Creative Thinking

**Lecture notes**
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials (alicia.smith@bc.bioc.ethz.ch)

**Literature**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**551-1299-00L **Bioinformatics**

**Objective**
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

**Prerequisites / notice**
Course participants have already acquired basic programming skills in UNIX, Python and R.

**Competencies**
- **Method-specific Competencies**: Concepts and Theories
- **Social Competencies**: Communication
- **Personal Competencies**: Creativity

**529-0731-00L **Nucleic Acids and Carbohydrates**

**Abstract**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymersases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines.

**Objective**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymersases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines.

**Content**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymersases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines.
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Mainly based on original literature, a detailed list will be distributed during the lecture.

Combines Concepts and Theories with Techniques and Technologies assessed

Analytical Competencies assessed

Problem-solving assessed

Cooperation and Teamwork assessed

Self-awareness and Self-reflection assessed

Self-direction and Self-management assessed

This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded.

Participants should be at a stage in their research where they can already start drafting parts of the report.

This course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded.

Participants should be at a stage in their research where they can already start drafting parts of the report.

D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

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<tbody>
<tr>
<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>R. Taylor</td>
</tr>
<tr>
<td>Abstract</td>
<td>This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report. Students will learn to: - Plan, draft, structure, and edit scientific reports - Produce reader-friendly sentences - Establish a clear and logical flow between sentences and paragraphs - Select formal vocabulary and use it in a generally accurate and correct manner - Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed</td>
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<tr>
<td>Content</td>
<td>The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions. Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded. Participants should be at a stage in their research where they can already start drafting parts of the report.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded. Participants should be at a stage in their research where they can already start drafting parts of the report.</td>
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<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>O</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
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<tr>
<td>Abstract</td>
<td>Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNA, current topics in protein biophysics and structural biology.</td>
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<tr>
<td>Objective</td>
<td>Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.</td>
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<tr>
<td>Lecture notes</td>
<td>Scripts on the individual topics can be found under <a href="http://www.mol.biol.ethz.ch/teaching">http://www.mol.biol.ethz.ch/teaching</a>.</td>
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<tr>
<td>Current topics</td>
<td>References will be given during the lectures.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
<th>Competencies</th>
<th>Literature</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>U. Kutay, F. Allain, T. Kleele, I. Zemp</td>
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<tr>
<td>Abstract</td>
<td>Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division &amp; growth, and cell migration.</td>
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<tr>
<td>Objective</td>
<td>The full-year course (551-0319-00 &amp; 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.</td>
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<tr>
<td>Content</td>
<td>Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.</td>
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<td>Lecture notes</td>
<td>Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (<a href="mailto:alicia.smith@bc.biol.ethz.ch">alicia.smith@bc.biol.ethz.ch</a>)</td>
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<td>Literature</td>
<td>Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.</td>
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<td>Prerequisites / notice</td>
<td>To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.</td>
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<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
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<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
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<tr>
<td>Abstract</td>
<td>Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Objective</td>
<td>This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Content</td>
<td>Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<td>Lecture notes</td>
<td>Updated handouts will be provided during the class.</td>
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<td>Literature</td>
<td>Current literature references will be provided during the lectures.</td>
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<tr>
<td>Prerequisites</td>
<td>English</td>
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<td>notice</td>
<td>The lecture &quot;Grundlagen der Biologie II: Mikrobiologie&quot; is the basis for this advanced lecture.</td>
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<tr>
<th>Competencies</th>
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<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>assessed</th>
<th>assessed</th>
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<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, A. Hajnal, O. Voinnet, University lecturers</td>
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<tr>
<td>Information</td>
<td>for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIOC348 at UZH.</td>
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<tr>
<td>Abstract</td>
<td>Please mind the ETH enrolment deadlines for UZH students: <a href="https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html">https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html</a></td>
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<td>Objective</td>
<td>Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<tr>
<td>Content</td>
<td>This course focuses on the concepts of classical and modern genetics and genomics.</td>
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<tr>
<td>Lecture notes</td>
<td>Scripts and additional material will be provided during the semester.</td>
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<td>Competencies</td>
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<td>Concepts and Theories</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td></td>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
<td>fostered</td>
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<td></td>
<td>Personal Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
<td>fostered</td>
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<td></td>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>fostered</td>
<td>fostered</td>
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<td></td>
<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
<td>fostered</td>
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<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<td></td>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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<tr>
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<th>Techniques and Technologies</th>
<th>assessed</th>
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<tbody>
<tr>
<td>551-1299-00L</td>
<td>Bioinformatics</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>S. Sunagawa, P. Beltrao, V. Boeva, A. Kahles, C. von Mering, N. Zamboni</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.</td>
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<td>Objective</td>
<td>Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.</td>
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<td>Prerequisites</td>
<td>Course participants have already acquired basic programming skills in UNIX, Python and R.</td>
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<td>notice</td>
<td>Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.</td>
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<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>assessed</th>
<th>assessed</th>
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<tr>
<td>529-0731-00L</td>
<td>Nucleic Acids and Carbohydrates</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>K. Lang, M. Frei, P. A. Kast, H. Wennemers</td>
</tr>
<tr>
<td>Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.</td>
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<tr>
<td>Abstract</td>
<td>Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines</td>
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</table>
Objective: Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content: Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes: No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature: Mainly based on original literature, a detailed list will be distributed during the lecture.

Competencies:
- **Subject-specific Competencies**: Concepts and Theories assessed
  - Techniques and Technologies assessed
- **Method-specific Competencies**: Analytical Competencies assessed
  - Problem-solving assessed
- **Social Competencies**: Communication assessed
  - Cooperation and Teamwork assessed
- **Personal Competencies**: Self-awareness and Self-reflection assessed
  - Self-direction and Self-management assessed

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-1401-00L</td>
<td>Advanced Protein Engineering (University of Zurich)</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>University lecturers</td>
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<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: BCH420</td>
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<td>Restricted to max. 10 students from ETH</td>
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<td>Mind the enrolment deadlines at UZH:</td>
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<td><a href="https://www.uzh.ch/cmsss/en/studies/application/deadline.s.html">https://www.uzh.ch/cmsss/en/studies/application/deadline.s.html</a></td>
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<td></td>
<td>Introduction into current research strategies in protein science.</td>
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<td></td>
<td>To understand current research strategies in protein science.</td>
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<td>Proteins have become an object of intense study in modern science, raging from their use as therapeutics to elucidating their structure and function in the cell. Moreover, it is now possible to engineer and evolve tailor-made proteins, opening up many new areas of science. This course will attempt to cover the frontiers and remaining challenges, emphasizing the biochemical foundations of the various approaches.</td>
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<td>Slides and references will be available on OLAT server.</td>
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<td><a href="https://www.olat.uzh.ch/olat/auth/repo/go?rid=600670219">https://www.olat.uzh.ch/olat/auth/repo/go?rid=600670219</a></td>
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<tr>
<td>Literature</td>
<td>-pdf's will be available on OLAT server.</td>
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<td><a href="https://www.olat.uzh.ch/olat/auth/repo/go?rid=600670219">https://www.olat.uzh.ch/olat/auth/repo/go?rid=600670219</a></td>
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<tr>
<td>Prerequisites</td>
<td>Solid knowledge in biochemistry strongly recommended</td>
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| 551-1153-00L | Systems Biology of Metabolism                                       | W    | 4    | 2V    | U. Sauer, N. Zamboni       |
|              | Number of participants limited to 15.                              |      |      |       |                            |
|              | Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts. |      |      |       |                            |
|              | Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology. |      |      |       |                            |
|              | The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics. |      |      |       |                            |
|              | Script and original publications will be supplied during the course. |      |      |       |                            |
| Lecture notes| The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry. |      |      |       |                            |
| Prerequisites | Solid knowledge in biochemistry strongly recommended                  |      |      |       |                            |

| 529-0004-01L | Classical Simulation of (Bio)Molecular Systems                      | W    | 6    | 4G    | P. H. Hünenberger, J. Dolenc, S. Riniker |
|              | Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS). |      |      |       |                            |
| Objective    | Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations. |      |      |       |                            |
| Content      | Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS). |      |      |       |                            |
| Lecture notes| The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture). |      |      |       |                            |
| Literature   | See: www.csms.ethz.ch/education/CSBMS                               |      |      |       |                            |
| Prerequisites | Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark). |      |      |       |                            |

For more information about the lecture: www.csms.ethz.ch/education/CSBMS
### 401-0649-00L Applied Statistical Regression

**Abstract**
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

**Lecture notes**
A script will be available.

**Literature**
- Faraway (2005): Linear Models with R
- Faraway (2006): Extending the Linear Model with R
- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
- Montgomery et al. (2006): Introduction to Linear Regression Analysis

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

### 401-6215-00L Using R for Data Analysis and Graphics (Part I)

**Abstract**
The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

**Objective**
The students will be able to use the software R for simple data analysis and graphics.

**Content**
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

**Lecture notes**
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

**Prerequisites / notice**
The course resources will be provided via the Moodle web learning platform.

Subscribing via Mystudies "automatically" makes you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.et.tzh.ch/course/view.php?id=20847
<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Semester</th>
<th>Credits</th>
<th>Type</th>
<th>Prerequisites / Notice</th>
<th>Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-1409-00L</td>
<td>RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>J. Hall, M. Stoffel, further lecturers</td>
<td>Does not take place this semester. Converge and processing of non-coding RNAs in relation to their biological functions, molecular biology, and chemical biology.</td>
</tr>
<tr>
<td>227-0939-00L</td>
<td>Cell Biophysics</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>T. Zambelli</td>
<td>Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.</td>
</tr>
</tbody>
</table>
Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

- Basics of theory of probability
- Boltzmann’s law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o’clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!
principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries)
directed evolution and protein engineering
chemical biology of ubiquitin and targeted protein degradation
advanced genetic code expansion methods (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing)

Lecture notes
A script will not be handed out. Handouts to the lecture will be provided through moodle.

Literature
Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Prerequisites / notice
Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<tr>
<td>Techniques and Technologies</td>
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<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>fostered</th>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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</table>

Social Competencies
| Communication                         | fostered |
| Cooperation and Teamwork              |          |
| Customer Orientation                  |          |
| Leadership and Responsibility         |          |
| Self-presentation and Social Influence|          |
| Sensitivity to Diversity              |          |
| Negotiation                           |          |

Personal Competencies
| Adaptability and Flexibility          | fostered |
| Creative Thinking                     | assessed |
| Critical Thinking                     | assessed |
| Integrity and Work Ethics             | fostered |
| Self-awareness and Self-reflection    |          |
| Self-direction and Self-management    |          |

Recommended Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>R. Taylor</td>
</tr>
</tbody>
</table>

Abstract
This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

Objective
Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

Content
The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Prerequisites / notice
Participants should be at a stage in their research where they can already start drafting parts of the report.

Major in Molecular Mechanisms of Disease

Elective Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-1299-00L</td>
<td>Bioinformatics</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>S. Sunagawa, P. Beltrao, V. Boeva, A. Kahles, C. von Mering, N. Zamboni</td>
</tr>
</tbody>
</table>

Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Competencies

551-0319-00L Cellular Biochemistry (Part I)

W 3 credits 2V U. Kutay, F. Allain, T. Kleele, I. Zemp

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into highly complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

551-0309-00L Concepts in Modern Genetics

W 6 credits 4V Y. Barral, A. Hajnal, O. Voinnet, University lecturers

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

Competencies

551-0317-00L Immunology I

W 3 credits 2V M. Kopf, A. Oxenius

Abstract
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Objective
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.
Introduction and historical background

- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lectures

University lecturers

Subject-specific Competencies

Development of the Nervous System (University of Zurich)

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4</td>
<td>3V</td>
<td>M. Fussenegger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
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<td>Objective</td>
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</tbody>
</table>

| 551-1303-00L    | Current Research Topics in Cellular Biochemistry | W    | 4    | 2S    | T. Kleee, V. Korkhov, G. Neurohr, V. Panse, M. Peter, A. E. Smith, F. van Drogen |
| Abstract        | During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies. |
| Objective       | Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to evaluate, critically discuss and write about scientific articles in the research area of cellular biochemistry, and they will identify open testable research questions. |
| Content         | Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with frontal presentations. Guided by a faculty expert, students develop domain knowledge of the research area associated with a primary paper, and alternate as discussion leaders to present the research topic. By the end of the semester, students will formulate their ideas about open testable research questions that extend from the published work. |
| Literature      | The literature will be provided during the course. |

| 376-1305-00L    | Development of the Nervous System (University of Zurich) | W    | 3    | 2V    | University lecturers |
| Notice          | No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. |
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

On successful completion of the module the student should be able to:
- identify key steps in development underlying neurological syndromes and diseases

The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/

From DNA to Diversity: the Evolution of Multicellular Organisms (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO344

Evolutionary Medicine for Infectious Diseases

This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

The focus is on primary literature, but for some parts the following text books provide good background information:

- Schmid Hempel 2011 Evolutionary Parasitology
- Stearns & Medzhitov 2016 Evolutionary Medicine

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Creativity and Critical Thinking

By the end of this module, each student should be able to:
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

The lecture notes Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

BIO142 Developmental Biology, BIO143 Neurobiology

Competencies

subject-specific Competencies

Concepts and Theories
Techniques and Technologies
Problem-solving
Project Management
Communication
Cooperation and Teamwork
Creative Thinking
Critical Thinking

Method-specific Competencies

assessed
fostered
fostered
fostered
assessed
fostered
assessed

Social Competencies

Personal Competencies

From DNA to Diversity: the Evolution of Multicellular Organisms (University of Zurich)

Mind the enrolment deadlines at UZH: https://www.olat.uzh.ch/olat/dmz/

551-0571-00L

551-0223-00L

Immunology III

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 335 of 2667
This course provides a detailed understanding of
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological textbook knowledge has evolved.

Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
- recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- optimization of B cell responses by intelligent design of new vaccines

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- overview of cytokines and their effector function
- co-stimulation (signals 1-3)
- dendritic cells
- evolution of the "danger" concept
- cells expressing pattern recognition receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

- milestones and current topics of innate immunity, antigen presentation, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

- milestones and current topics of innate immunity, antigen presentation, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

- original and review articles will be distributed by the respective lecturer.

- Literaturunterlagen werden vor Beginn des Kurses auf folgender Website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

551-1171-00L Immunology: From Milestones to Current Topics

W 4 credits 2S B. Ludewig, N. Pikor, University lecturers

Abstract
Milestones in Immunology: on old concepts and modern experiments

Objective
The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Content
- milestones and current topics of innate immunity, antigen presentation, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.
- original and review articles will be distributed by the respective lecturer.

Lecture notes
Original and review articles will be distributed by the respective lecturer.

Literature
Literaturunterlagen werden vor Beginn des Kurses auf folgender Website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies

Social Competencies
- Communication

Personal Competencies
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

752-4009-00L Molecular Biology of Foodborne Pathogens

W 3 credits 2V M. Loesner, A. Harms, M. Schupppler, E. Slack

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with a focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
- molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break !

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication

Personal Competencies
- Creative Thinking
- Critical Thinking

376-1305-01L Molecular Neurophysiology: From Molecules to Systems

W 3 credits 2V G. Schratt, R. Fiore, W. von der Behrens, J. Winterer

Abstract
Information for UZH students: Enrolment to this course unit only possible at ETH. Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-
The course covers the physiology of nerve cells, from the single cell through the neuronal network to the systemic level. The focus is on molecular and cellular mechanisms – synaptic transmission, signal transduction, gene expression, synaptic plasticity.

Based on an understanding of molecular and cellular mechanisms, the aim is to provide a deepened insight into neurophysiological processes underlying complex brain functions – learning/memory, sleep, sensory.

First, basic molecular and cellular mechanisms in nerve cells (excitability, neurotransmission, signal transduction, gene expression, synaptic plasticity) are introduced. Afterwards, their significance for selected neurophysiological processes (learning/memory, sleep, sensory) will be illuminated.

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle.

Literature: The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle.

Competencies
- Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies

551-1407-00L RNA Biology Lecture Series I: Transcription & Processing & Translation

W 4 credits 2V F. Allain, N. Ban, S. Jonas, U. Kutay, further lecturers

Abstract
This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

Objective
The focus is on developing a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key processes. This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

Content
- Transcription & 3'end formation: splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP biogenesis & nuclear export, mRNA surveillance & mRNA turnover; signal transduction & RNA.

Prerequisites / notice
Basic knowledge of cell and molecular biology.

551-1409-00L RNA Biology Lecture Series II: Non-Coding RNAs:

W 4 credits 2V J. Hall, M. Stoffel, further lecturers

Abstract
This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

Objective
The course students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

Content
- Micro RNAs: computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; tRNA biology.

Prerequisites / notice
Basic knowledge of cell and molecular biology.

551-1153-00L Systems Biology of Metabolism

Number of participants limited to 15.

W 4 credits 2V U. Sauer, N. Zamboni

Abstract
Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective
Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content
The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes
Script and original publications will be supplied during the course.

Prerequisites / notice
The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

376-0300-00L Essentials in Translational Science

W 3 credits 2G J. Goldhahn

Abstract
Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicine). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

Objective
After completing this course, students will be able to understand: Principles of translational science including medical device development, intellectual property, regulatory environment and project management.

Content
- What is translational science and what is it not including: How to identify need?
- How to choose the appropriate research type and methodology
- How to measure success?
- How are medical devices developed?
- How to handle IP in the development process?
- How does the regulatory environment impact innovation?
- How to manage complex development projects?
- Positive and negative examples will be illustrated by distinguished guest speakers.

Literature
- Principles of Biomedical Sciences and Industry: Translating Ideas into Treatments
  https://doi.org/10.1002/9783527624014

Prerequisites / notice
4x online input lecture followed by case preparation and symposium
Competencies

### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: fostered

### Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Negotiation: fostered

### Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### Recommended Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>R. Taylor</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.</td>
<td></td>
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</tbody>
</table>
| **Objective** | Students will learn to:  
- Plan, draft, structure, and edit scientific reports  
- Produce reader-friendly sentences  
- Establish a clear and logical flow between sentences and paragraphs  
- Select formal vocabulary and use it in a generally accurate and correct manner  
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed |
| **Content** | The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions. |
| **Prerequisites / notice** | Participants should be at a stage in their research where they can already start drafting parts of the report. |

### Elective Major: Molecular Plant Biology

### Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0311-00L</td>
<td>Molecular Life of Plants</td>
<td>O</td>
<td>6</td>
<td>4V</td>
<td>S. C. Zeeman, K. Bomblies, O. Voinnet</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The new course &quot;Molecular Life of Plants&quot; reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels. The goal of &quot;Molecular Life of Plants&quot; is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.</td>
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</table>
| **Content** | The course "Molecular Life of Plants" will cover the following topics:  
- Seed structure and physiology, their dormancy and germination.  
- Seedling establishment and early development.  
- Structure and Function of Meristems, including stem cells.  
- Plant organ development (leaves, roots, flowers etc.).  
- Plant reproduction.  
- The plant vasculature for long-distance transport and other specialized tissues.  
- Sensing and responding to the abiotic environment.  
- Plant-microbe interactions; beneficial friends or pathogenic foes?  
- Polyploidy; the benefits, problems and solutions to of multiple genomes.  
- Photosynthesis and carbon partitioning.  
- Photorespiration and the evolution of C4 metabolism.  
- Starch biosynthesis and degradation.  
- Chloroplast development and chlorophyll biosynthesis.  
- Senescence mechanisms in plants.  
- General principles of RNA silencing.  
- MicroRNAs: discovery, general principle and modes of action at the cellular and system levels.  
- Chromatin-based RNA silencing.  
- Antiviral RNA silencing.  
- RNA silencing & defense against non-viral pathogens.  
- RNA silencing movement and amplification. |

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 338 of 2667
### Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0120-00L</td>
<td>Plant Biology Colloquium (Autumn Semester)</td>
<td>W</td>
<td>2 credits</td>
<td>1K</td>
<td>S. C. Zeeman, K. Bomblies, O. Voinnet</td>
</tr>
</tbody>
</table>

**Abstract**
Current topics in Molecular Plant Biology presented by internal and external speakers from academia.

**Objective**
Getting insight into actual areas and challenges of Molecular Plant Biology.

**Content**

### Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0120-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

**Abstract**
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

**Objective**
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

**Lecture notes**
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

**Literature**
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0120-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, A. Hajnal, O. Voinnet, University lecturers</td>
</tr>
</tbody>
</table>

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-special-students-university-of-zurich.html

**Abstract**
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**
This course focuses on the concepts of classical and modern genetics and genomics.

**Content**
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**
Scripts and additional material will be provided during the semester.
Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Method-specific Competencies

- assessed
- assessed
- assessed
- assessed
- fostered
- fostered
- fostered
- fostered
- fostered
- fostered

Social Competencies

- assessed
- fostered
- assessed
- assessed
- fostered
- fostered
- fostered
- fostered
- fostered
- fostered

Personal Competencies

- assessed
- fostered
- assessed
- fostered
- fostered

551-0313-00L Microbiology (Part I)

W 3 credits 2V

Objective

This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content

Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes

Updated handouts will be provided during the class.

Literature

Current literature references will be provided during the lectures.

Prerequisites / notice

The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

551-0319-00L Cellular Biochemistry (Part I)

W 3 credits 2V

Objective

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular biology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular concept of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Lecture notes

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Competencies

- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Critical Thinking

701-2413-00L Evolutionary Genetics

W 6 credits 4V

Objective

The aim of the course is to provide students with a solid introduction to the fields of population and quantitative genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content

Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory. Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher's fundamental theorem. Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

Lecture notes

Handouts

Literature


Competencies

- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Critical Thinking

529-0731-00L Nucleic Acids and Carbohydrates

W 6 credits 3G

Objective

The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Content

Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory. Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher's fundamental theorem. Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

Lecture notes

Handouts

Literature


Competencies

- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Critical Thinking

529-0732-00L Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester)

W 6 credits 3G

Objective

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular biology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular concept of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Lecture notes

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Competencies

- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Critical Thinking

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

Abstract

Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines
Objective
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication assessed

Theoretical Competencies
Cooperation and Teamwork assessed

Personal Competencies
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

551-1299-00L Bioinformatics W 6 credits 4G S. Sunagawa, P. Beltrao, V. Boeva, A. Kahles, C. von Mering, N. Zamboni

Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed

Social Competencies
Communication fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-5121-00L</td>
<td>Insect Ecology</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>C. De Moraes, N. Stanczyk</td>
</tr>
<tr>
<td>Abstract</td>
<td>This is an introductory class on insect ecology. During the course you will learn about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes in-person lectures, small group discussions and outside readings.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The aim of the course is for you to be able to describe examples of insect interactions and evaluate their impact on broader ecosystems. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutual and parasitic interactions, and examining insect ecology in an evolutionary context.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Provided to students through Moodle</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Selected required readings (peer reviewed literature). Optional recommended readings with additional information.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Competencies       | Subject-specific Competencies
|                    | Concepts and Theories assessed |
|                    | Social Competencies
|                    | Communication fostered |
|                    | Personal Competencies
|                    | Critical Thinking assessed |
| 551-1153-00L       | Systems Biology of Metabolism      | W    | 4    | 2V    | U. Sauer, N. Zamboni |
| Number of participants limited to 15. |
| Abstract           | Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts. |
| Objective          | Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology. |
| Content            | The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics. |
| Lecture notes      | Script and original publications will be supplied during the course. |
| Prerequisites / notice | The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry. |
| 751-4504-00L       | Plant Pathology I                  | W    | 2    | 2G    | B. McDonald |

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 341 of 2667
Abstract
Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems.

Objective
Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.

Content
Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytotoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.


Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.


Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Techniques and Technologies

Lecture notes
Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

551-1407-00L RNA Biology Lecture Series I: Transcription & Processing & Translation

Abstract
This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

Objective
The students should obtain an understanding of these processes, which are at work during gene expression.

Content
Transcription & 3'end formation; splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP processing, alternative splicing, editing, export and translation.

Prerequisites / notice
Basic knowledge of cell and molecular biology.

551-1409-00L RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

Abstract
This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

Objective
The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

Content
Micro RNAs; computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs: nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; RNA biology.

Prerequisites / notice
Basic knowledge of cell and molecular biology.

529-0733-02L Chemical Biology and Synthetic Biochemistry

Abstract
Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.
Objective

After taking this course, students should be capable of the following:

A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context.

B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro.

C) Critically analyze and assess current chemical biology articles.

D) Question the approaches learned and apply them to new biological problems.

Content

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Advanced genetic code expansion methods (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing)

directed evolution and protein engineering

chemical biology of ubiquitin and targeted protein degradation

Lecture notes

A script will not be handed out. Handouts to the lecture will be provided through moodle.

Literature

Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Prerequisites / notice

Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course "Introduction to Programming", which takes place in Basel before the start of the semester.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving

Personal Competencies

- Creative Thinking
- Critical Thinking

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS.

Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phyldynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.

Abstract

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Attendees will learn what information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

* epidemiology
* pathogen evolution
* macroevolution of species
### Using R for Data Analysis and Graphics (Part II)

- **Course Code:** 401-6217-00L
- **Credits:** 1.5 credits
- **Lecturer:** M. Mächler

#### Abstract
The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

#### Objective
The students will be able to use the software R efficiently for data analysis, graphics and simple programming.

#### Content
Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options;
- Extending basic R: packages

#### Competencies
- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Media and Digital Technologies
  - Problem-solving
- **Social Competencies**
  - Cooperation and Teamwork
- **Personal Competencies**
  - Creative Thinking

#### Lecture notes
**Prerequisites / notice**
Basic knowledge of R equivalent to "Using R .. (part I)" is a prerequisite for this course.

#### Competencies
- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
- **Social Competencies**
  - Communication
- **Personal Competencies**
  - Adaptability and Flexibility
  - Critical Thinking
  - Self-direction and Self-management

### Applied Statistical Regression

- **Course Code:** 401-0649-00L
- **Credits:** 5 credits
- **Prerequisites:** 1G
- **Lecturer:** M. Dettling

#### Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

#### Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lectures and exercises will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

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<th>Competencies</th>
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<td>Method-specific Competencies</td>
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<td>Social Competencies</td>
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<td>Personal Competencies</td>
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**Alternative Crops**

This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

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<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>R. Taylor</td>
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</table>

**Abstract**

Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

**Content**

The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded.

**Literature**

- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
- Montgomery et al. (2006): Introduction to Linear Regression Analysis

**Prerequisites / notice**

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

**Recommended Master Courses**

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Prerequisites / notice

Participants should be at a stage in their research where they can already start drafting parts of the report.

### Major in Ecology and Evolution

#### Compulsory Concept Courses

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<th>Number</th>
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<tbody>
<tr>
<td>701-2413-00L</td>
<td>Evolutionary Genetics</td>
<td>O</td>
<td>6 credits</td>
<td>4V</td>
<td>T. Städler, A. Widmer, S. Fior, M. Fischer, J. Stapley</td>
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</table>

**Abstract**
The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

**Objective**
The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

**Content**
Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.

Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher's fundamental theorem.

Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation

**Lecture notes**
Handouts

**Literature**

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: fostered

- **Personal Competencies**
  - Critical Thinking: fostered

### Elective Compulsory Master Courses

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<tr>
<td>701-1409-00L</td>
<td>Research Seminar: Ecological Genetics</td>
<td>W</td>
<td>2 credits</td>
<td>1S</td>
<td>S. Fior</td>
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**Abstract**
In this research seminar we will critically discuss recent publications on current topics in Ecological Genetics.

**Objective**
It is our aim that participants gain insight into current research topics and approaches in Ecological Genetics and learn to critically assess and appreciate scientific publications in this field.

**Lecture notes**
None

**Literature**
Selected required readings (peer reviewed literature). Optional recommended readings with additional information.

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Communication: fostered
  - Cooperation and Teamwork: fostered

- **Personal Competencies**
  - Critical Thinking: assessed

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<tr>
<td>751-5121-00L</td>
<td>Insect Ecology</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>C. De Moraes, N. Stanczyk</td>
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**Abstract**
This is an introductory class on insect ecology. During the course you will learn about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes in-person lectures, small group discussions and outside readings.

**Objective**
The aim of the course is for you to be able to describe examples of insect interactions and evaluate their impact on broader ecosystems. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutual and parasitic interactions, and examining insect ecology in an evolutionary context.

**Lecture notes**
Provided to students through Moodle

**Literature**
Selected required readings (peer reviewed literature). Optional recommended readings with additional information.

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories: assessed

- **Social Competencies**
  - Communication: fostered

- **Personal Competencies**
  - Critical Thinking: assessed

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<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
</tbody>
</table>

**Abstract**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Objective**
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed

- **Personal Competencies**
  - Critical Thinking: assessed

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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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</table>
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies. The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

A script will be available.

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

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<td>Self-direction and Self-management</td>
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3 credits

This course provides the ecological systems' knowledge needed to question applied sustainability solutions. We will critically assess the complexity of current environmental issues, illustrating basic ecological concepts and principles. Our central aim is to balance participants’ respect for complexity with a sense of possibility by providing examples from the vast solution space offered by ecological systems, such as e.g. green infrastructure to manage water.

At the end of the course... you know how to structure your inquiry and how to proceed the analysis when faced with a complex environmental issue. You can formulate the relevant questions, find answers (supported by discussions, input from the lecturers and the literature), and you are able to present your conclusions clearly and cautiously.

...you understand the complexity of interactions and structures in ecosystems. You know how ecosystem processes, functions and services interact and feed back across multiple spatio-temporal scales (in general, plus in depth case examples).

...you understand that biodiversity and the interaction between organisms are an integral part of ecosystems. You are aware that the link between biodiversity and process/function/service is rarely fully understood. You know how to honestly deal with this lack of understanding and can nevertheless find, critically analyse and communicate solutions.

...you understand the importance of ecosystem services for society.

...you have an overview of the methods of ecosystem research and have a deeper insight into some of them, e.g. ecosystem observation, manipulation and modelling.

...you have reflected on ecology as a young discipline at the heart of significant applied questions.

This course provides the ecological systems' knowledge needed to question applied sustainability solutions. We will critically assess the complexity of current environmental issues, illustrating basic ecological concepts and principles. Our central aim is to balance participants' respect for complexity with a sense of possibility by providing examples from the vast solution space offered by ecological systems, such as e.g. green infrastructure to manage water.

The course is structured around four larger topical areas: (1) Integrated Water Management -- Green infrastructure (land management options) as an alternative to engineered solutions (e.g. large reservoirs) in flood and drought management; (2) Fire dynamics, the water cycle and biodiversity -- The surprising dynamics of species life cycles and populations in arid landscapes; (3) Rewilding, e.g. reintroducing apex predators (e.g. wolves), or large ungulates (e.g. bisons) in protected areas -- A nature conservation trend with counterintuitive effects; (4) Coupling of aquatic and terrestrial systems: carbon, nitrogen and phosphorus transfers of global importance on landscape scale.

Case descriptions, commented glossary and a list of literature and further resources per case.

It is not essential to borrow/buy the following books. We will continuously provide excerpts and other literature during the course.

- Schulze et al. (2005) Plant Ecology; Springer.
The course combines elements of a classic lecture, group discussions and problem based learning. It is helpful, but not essential to be familiar with the "seven stages" method (see e.g. course 701-0352-00L "Analysis and Assessment of Environmental Sustainability" by Christian Pohl et al.).

### 401-6215-00L Using R for Data Analysis and Graphics (Part I)

**W 1.5 credits 1G A. Hauser**

**Abstract**
The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

**Objective**
The students will be able to use the software R for simple data analysis and graphics.

**Content**
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

**Lecture notes**
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

**Prerequisites / notice**
The course resources will be provided via the Moodle web learning platform. Subscribing via Mystudies "automatically" makes you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=20847

**Competencies**

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### 401-6217-00L Using R for Data Analysis and Graphics (Part II)

**W 1.5 credits 1G M. Mächler**

**Abstract**
The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

Note: This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

**Objective**
The students will be able to use the software R efficiently for data analysis, graphics and simple programming.

**Content**
The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course builds on Part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options;
- Extending basic R: packages.

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

**Lecture notes**
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

**Prerequisites / notice**
Basic knowledge of R equivalent to "Using R... (Part I)" (= 401-6215-00L) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=20848

**Competencies**

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Abstract

Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Objective

Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.

Content

Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.
Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.
Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.
Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytotoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.
Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria triticum blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).
Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.
Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.
Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.
Week 10 Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.
Week 12 Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.
Week 13 Cultural control methods: fertilizers, crop rotations.

Lecture notes

Week 14  Open lecture.

Competencies

Subject-specific Competencies

Computational Biology

W 6 credits 3G+2A

T. Vaughan, C. Magnus, T. Stadler

636-0017-00L

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.
Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
* Yang, Z. 2006. Computational Molecular Evolution.
* Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Competencies

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Method-specific Competencies

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Personal Competencies

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Social Competencies

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701-1471-00L Ecological Parasitology

W 3 credits 1V+1P F. Feijen, J. Jokela, C. Vorburger

Abstract

The course will not take place fall semester 2024.

Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

Objectives

1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

Content

Lectures:

1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria).

Practical exercises:

1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).
2. Examination of parasites in amphipods (identification and examination of effects on hosts).
3. Examination of parasitoids of aphids.

The three practicals will take place at the 03.10.2023, the 17.10.2023 and the 07.11.2023 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

701-1703-00L Evolutionary Medicine for Infectious Diseases

W 3 credits 2G A. Hall

Abstract

This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective

Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (~20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature

The focus is on primary literature, but for some parts the following text books provide good background information:

Schmid Hempel 2011 Evolutionary Parasitology
Steens & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.
Communication fostered

Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on sexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

Prerequisites / notice

Prerequisites: Basic mathematics (linear algebra, calculus, probability)

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies

Problem-solving fostered

Social Competencies

Communication assessed
Cooperation and Teamwork fostered

Personal Competencies

Critical Thinking fostered

Advanced Ecological Processes

701-0328-00L

Abstract

This course presents a broad overview of the key processes structuring ecological populations and communities, with a particular focus on understanding and managing global change impacts.

Objective

COURSE GOALS

In this course, students will develop an integrated knowledge of how ecological theory can help us understand and manage ecological responses to global change. Specifically, the course goals are to:

- Introduce students to the major ecological processes that together shape the composition and abundance of species within ecological communities.
- Provide insight to students on the ecological impacts of anthropogenic change, and how an understanding of ecological processes can help us predict these ecological impacts and design conservation / restoration actions to mitigate their negative impacts.
- Teach students to critically summarize and analyze primary ecological literature, understanding how ecological studies contribute to our knowledge, how to critically evaluate their strengths and weaknesses, and practice designing follow up studies.

LEARNING OBJECTIVES

The learning objectives follow from the course goals. After attending this course, students should be able to:

- Describe key processes affecting the size of populations and abundance of species within ecological communities.
- Critically evaluate evidence and conclusions presented in primary ecological literature based on your understanding of these ecological processes.
- Apply knowledge of ecological processes to make predictions about the major responses of ecological communities to anthropogenic perturbations.

Content

We will explore how ecological theories can provide insight into the effects of anthropogenic change as well as guide management to undo undesired impacts. Collectively, this requires us to focus on classic problems in ecology (for examples, competitive coexistence, top-down impacts of predators, diversity-ecosystem function relationships, the role of dispersal in spread).

The course is taught in a flipped format. Generally (with the exception of a few weeks), there will be online materials for students to watch or read during the first hour of class (lecture videos, readings), and the class will meet in person for the second half of class. The in person portions of the class will have students participate in activities to learn the content, including paper discussions, groupwork, and presentations. Students are also required to submit a written assignment.

Lecture notes

All course materials (videos, lecture notes, primary literature) will be provided on the course moodle.

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Analytical Competencies assessed

Problem-solving fostered

Social Competencies

Communication assessed

Cooperation and Teamwork fostered

Personal Competencies

Critical Thinking fostered

Integrity and Work Ethics fostered

Applied Bioinformatics: Microbiomes

752-5500-00L

Abstract

Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

Lecture notes

No.

Literature


Competencies

Method-specific Competencies

Creative Thinking fostered

Personal Competencies

Critical Thinking fostered

Self-direction and Self-management fostered

LEARNING OBJECTIVES

The learning objectives follow from the course goals. After attending this course, students should be able to:

- Describe key processes affecting the size of populations and abundance of species within ecological communities.
- Critically evaluate evidence and conclusions presented in primary ecological literature based on your understanding of these ecological processes.
- Apply knowledge of ecological processes to make predictions about the major responses of ecological communities to anthropogenic perturbations.
Objective
Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

Content
1. Introduction to microbiomes and microbial bioinformatics toolkit. Python, Pandas, Jupyter, GitHub, visualization libraries for Python.
3. Microbial diversity, function, and ecology. Molecular ecology, diversity metrics, ordination methods.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice
No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

Students will bring and work on their own laptop computers.

All software used in the course is free and open-source.

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Social Competencies
Communication
Social Competencies
Creative Thinking
Critical Thinking
Self-direction and Self-management

Personal Competencies

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<th>Elective Concept Courses</th>
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<td>551-0310-00L</td>
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Abstract
Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-special-uni-berlin-uni-berlin.html

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes
Updated handouts will be provided during the class.

Prerequisite / notice
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

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Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.
Objective

Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites

Course participants have already acquired basic programming skills in UNIX, Python and R.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Recommended Master Courses

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<tr>
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<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2</td>
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<td>R. Taylor</td>
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Abstract

This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

Objective

Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

Content

The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded.

Prerequisites

Participants should be at a stage in their research where they can already start drafting parts of the report.

Major in Systems Biology

Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

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<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>U. Kutay, F. Allain, T. Kleele, I. Zemp</td>
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Abstract

Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Enrolment for UZH students: Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-
Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Self-presentation and Social Influence fostered

Personal Competencies
- Creative Thinking assessed
- Critical Thinking fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

551-0313-00L Microbiology (Part I) W 3 credits 2V W. D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad

Abstract
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes
Updated handouts will be provided during the class.

Literature
Current literature references will be provided during the lectures.

Prerequisites / notice
English
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

551-1299-00L Bioinformatics W 6 credits 4G S. Sunagawa, P. Beltrao, V. Boeva, A. Kahles, C. von Mering, N. Zamboni

Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

4444 Elective Compulsory Master Courses I: Computation

Number Title Type ECTS Hours Lecturers
636-0007-00L Computational Systems Biology W 6 credits 3V+2U J. Stelling

Abstract
Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.
**Content**

Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

**Lecture notes**

http://www.csb.ethz.ch/education/lectures.html


**Literature**


3G, D. Bopp

**ECTS**

4 credits

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**Spatio-Temporal Modelling in Biology**

**Lecture notes**

All lecture material will be made available online via Moodle.

**Prerequisites / notice**

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

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**Elective Compulsory Master Courses II: Biology**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>W</td>
<td>4 credits</td>
<td>2V</td>
<td>U. Sauer, N. Zamboni</td>
</tr>
<tr>
<td>551-0571-00L</td>
<td>From DNA to Diversity: the Evolution of Multicellular Organisms (University of Zurich)</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>A. Hajnal, D. Bopp</td>
</tr>
</tbody>
</table>

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**Notice**

Number of participants limited to 15.

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Script and original publications will be supplied during the course.

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

---

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

The evolution of the various body-plans is investigated by means of comparison of developmentally essential control genes of molecularly analysed model organisms.
Evolutionary Dynamics

T. Zambelli

Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

By the end of this module, each student should be able to:
- recognize the universal principles underlying the development of different animal body plans.
- explain how the genes encoding the molecular toolkit have evolved to create animal diversity.
- relate changes in gene structure or function to evolutionary changes in animal development.

Key skills:
- By the end of this module, each student should be able to:
  - present and discuss a relevant evolutionary topic in an oral presentation
  - select and integrate key concepts in animal evolution from primary literature
  - participate in discussions on topics presented by others

636-0009-00L

Evolutionary Dynamics

W 6 credits 2V+1U+2A N. Beerenwinkel

Abstract

Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution. The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

Objective

Theory and corresponding exercises are merged together during the classes.

Lecture notes

I am willingly available Mondays 17:00 o'clock - 18:00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!
Literature


As further deepening:


Prerequisites / notice

Participants need a good command of
• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>assessed</td>
<td>fostered</td>
<td>fostered</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<tr>
<td></td>
<td>assessed</td>
<td>assessed</td>
<td>Customer Orientation</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>fostered</td>
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<tr>
<td></td>
<td>fostered</td>
<td>assessed</td>
<td>Self-presentation and Social Influence</td>
<td>fostered</td>
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<td></td>
<td></td>
<td>assessed</td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>assessed</td>
<td>Negotiation</td>
<td>fostered</td>
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</table>

Prerequisites / notice

Participants should be at a stage in their research where they can already start drafting parts of the report.

Recommended Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>R. Taylor</td>
</tr>
</tbody>
</table>

Abstract

This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

Objective

Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

Content

The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Prerequisites / notice

Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded.

Research Projects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1801-10L</td>
<td>Research Project I</td>
<td>O</td>
<td>16</td>
<td>34A</td>
<td>Lecturers</td>
</tr>
<tr>
<td></td>
<td>Only for Biology Master, Programme Regulations 2023</td>
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</tbody>
</table>

Abstract

Research projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1801-11L</td>
<td>Research Project II</td>
<td>O</td>
<td>16</td>
<td>34A</td>
<td>Lecturers</td>
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<tr>
<td></td>
<td>Only for Biology Master, Programme Regulations 2023</td>
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</tbody>
</table>

Abstract

Research projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1800-10L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>32</td>
<td>69D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to
The Master research will be carried out on a theme in the chosen subject area and must be completed with a written report (Thesis) within six months.

- **Master Studies (Programme Regulations 2018)**
- **Elective Major: Cell Biology**
  - **Elective Compulsory Concept Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>U. Kutay, F. Allain, T. Kleele, I. Zemp</td>
</tr>
</tbody>
</table>

**Abstract**

Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**

The full-year course focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

**Content**

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

**Prerequisites / notice**

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**Lecture notes**

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

**Literature**

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

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**551-0309-00L Concepts in Modern Genetics**

*Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.*

*Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html*

**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics.

**Content**

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**

Scripts and additional material will be provided during the semester.

---

**551-0317-00L Immunology I**

**Abstract**

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.
Objective
Introduction into structural and functional aspects of the immune system.

Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien".

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Competencies
Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Technologies: assessed

Method-specific Competencies
Analytical Competencies: fostered
Decision-making: fostered
Problem-solving: fostered
Project Management: fostered

Social Competencies
Communication: fostered
Cooperation and Teamwork: fostered

Personal Competencies
Adaptability and Flexibility: fostered
Creative Thinking: fostered
Critical Thinking: assessed
Self-direction and Self-management: fostered

551-1299-00L Bioinformatics W 6 credits 4G S. Sunagawa, P. Beltrao, V. Boeva, A. Kahles, C. von Mering, N. Zamboni

Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Competencies
Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Technologies: assessed

Method-specific Competencies
Analytical Competencies: assessed
Decision-making: assessed
Media and Digital Technologies: assessed
Problem-solving: assessed
Project Management: fostered

Social Competencies
Communication: fostered
Cooperation and Teamwork: fostered

Personal Competencies
Adaptability and Flexibility: fostered
Creative Thinking: assessed
Critical Thinking: assessed
Integrity and Work Ethics: fostered
Self-awareness and Self-reflection: fostered
Self-direction and Self-management: fostered

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0512-00L</td>
<td>Current Topics in Molecular and Cellular Neurobiology</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Suter</td>
</tr>
</tbody>
</table>

Does not take place this semester.

Abstract
The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.

Objective
The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

Content
You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

Lecture notes
Presentations will be made available after the seminars.
Prerequisites / notice
You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

551-0571-00L From DNA to Diversity: the Evolution of Multicellular Organisms (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: BIO336
Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
The evolution of the various body-plans is investigated by means of comparison of developmentally essential control genes of molecularly analysed model organisms.

Objective
By the end of this module, each student should be able to
- recognize the universal principles underlying the development of different animal body plans.
- explain how the genes encoding the molecular toolkit have evolved to create animal diversity.
- relate changes in gene structure or function to evolutionary changes in animal development.
Key skills:
By the end of this module, each student should be able to
- present and discuss a relevant evolutionary topic in an oral presentation
- select and integrate key concepts in animal evolution from primary literature
- participate in discussions on topics presented by others

551-1117-00L Cutting Edge Topics: Immunology and Infection Biology
Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIO636 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Abstract
Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion.

Objective
Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion.
The aim of this course is to confront students with current research topics and with scientific presentation. The course offers the opportunity to gain in depth knowledge about diverse topics which are often only briefly touched in the concept courses and to engage in discussion with experts in the field.

Content
Immunology and infection biology.
The specific topics are variable and depend each semester on the list of invited experts.

Lecture notes
Current research data (often not yet published) are presented in this seminar series. There is no script and we are not allowed to record or distribute the contents of the seminars. Thus, the ability of students to extract the most relevant points of each seminar is promoted, which is an important skill for the future attendance of scientific meetings.

Literature
Often parts of the presented seminars have already been published by the respective speakers and the respective primary research can be retrieved from scientific journals.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assed
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking fostered
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management assessed

551-1153-00L Systems Biology of Metabolism
Number of participants limited to 15.

Abstract
Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective
Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.
The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

### 551-1177-00L Immunology: From Milestones to Current Topics

**W 4 credits 2S**

**B. Ludewig, N. Pikor, University lecturers**

**Abstract**

Milestones in Immunology: on old concepts and modern experiments

**Objective**

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

**Content**

Milestones and current topics of innate immunity, antigen presentation, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

**Lecture notes**

Script and original publications will be supplied during the course.

**Literature**

Literaturunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

### 551-1303-00L Current Research Topics in Cellular Biochemistry

**W 4 credits 2S**

**T. Kleele, V. Korkhov, G. Neurohr, V. Panse, M. Peter, A. E. Smith, F. van Drogen**

**Abstract**

During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

**Objective**

Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to evaluate, critically discuss and write about scientific articles in the research area of cellular biochemistry, and they will identify open testable research questions.

**Content**

Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with frontal presentations. Guided by a faculty expert, students develop domain knowledge of the research area associated with a primary paper, and alternate as discussion leaders to present the research topic. By the end of the semester, students will formulate their ideas about open testable research questions that extend from the published work.

**Literature**

The literature will be provided during the course.

**Prerequisites / notice**

The course will be taught in English.

### 551-1407-00L RNA Biology Lecture Series I: Transcription & Processing & Translation

**W 4 credits 2V**

**F. Allain, N. Ban, S. Jonas, U. Kutay, further lecturers**

**Abstract**

This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

**Objective**

The students should obtain an understanding of these processes, which are at work during gene expression.

**Content**

Transcription & 3'end formation; splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP biogenesis & nuclear export, mRNA surveillance & mRNA turnover; signal transduction & RNA.

**Prerequisites / notice**

Basic knowledge of cell and molecular biology.

### 551-1409-00L RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

**W 4 credits 2V**

**J. Hall, M. Stoffel, further lecturers**

**Abstract**

This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

**Objective**

The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

**Content**

Micro RNAs; computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; TRNA biology. http://www.nccr-rna-and-disease.ch/tiki-index.php?page=LectureSeries

**Prerequisites / notice**

Basic knowledge of cell and molecular biology.

### 551-2223-00L Immunology III

**W 4 credits 2V**

**M. Kopf, S. B. Freigang, S. R. Leibundgut, F. Mair, A. Ovenius, C. Schneider, E. Slack, R. Spörri, further lecturers**

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.
Abstract
This course provides a detailed understanding of
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies
Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective
Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T cells and their effectormechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differeentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice
Immunology I and II recommended but not compulsory

227-0939-00L Cell Biophysics W 6 credits 4G T. Zambelli

Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective
Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content
• Basics of theory of probability
• Boltzmann's law
• Entropy maximization and Gibbs free energy minimization
• Ligand-receptor: two-state systems and the MWC model
• Random walks, diffusion, crowding
• Electrostatics for salty solutions
• Elasticity: fibers and membranes
• Molecular motors
• Action potential: Hodgkin-Huxley model
• Photosynthesis and vision
• Gene regulation
• Development: Turing patterns

Theory and corresponding exercises are merged together during the classes.

Lecture notes
No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o'clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!

Literature

As further deepening:

Prerequisites / notice
Participants need a good command of
• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.
### Molecular Neurophysiology: From Molecules to Systems
**Module Code:** 376-1305-01L
**Credits:** 3
**Lecturers:** G. Schratt, R. Fiore, W. von der Behrens, J. Winterer

**Abstract**
The course covers the physiology of nerve cells, from the single cell through the neuronal network to the systemic level. The focus is on molecular and cellular mechanisms – synaptic transmission, signal transduction, gene expression, synaptic plasticity.

**Objective**
Based on an understanding of molecular and cellular mechanisms, the aim is to provide a deepened insight into neurophysiological processes underlying complex brain functions – learning/memory, sleep, sensory.

**Content**
First, basic molecular and cellular mechanisms in nerve cells (excitability, neurotransmission, signal transduction, gene expression, synaptic plasticity) are introduced. Afterwards, their significance for selected neurophysiological processes (learning/memory, sleep, sensory) will be illuminated.

**Literature**
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle.

**Competencies**

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<tr>
<th>Subject-specific Competencies</th>
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| Social Competencies | Communication | fostered |
|                    | Cooperation and Teamwork | fostered |
|                    | Customer Orientation     | fostered |
|                    | Leadership and Responsibility | fostered |
|                    | Self-presentation and Social Influence | fostered |
|                    | Sensitivity to Diversity  | assessed |
|                    | Negotiation              | fostered |

| Personal Competencies | Adaptability and Flexibility | assessed |
|                      | Creative Thinking           | assessed |
|                      | Critical Thinking           | assessed |
|                      | Integrity and Work Ethics   | assessed |
|                      | Self-awareness and Self-reflection | assessed |
|                      | Self-direction and Self-management | assessed |

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### Development of the Nervous System (University of Zurich)
**Module Code:** 376-1305-00L
**Credits:** 3
**Lecturers:** University lecturers

**Abstract**
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

**Objective**
On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

**Key skills**
On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

**Content**
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

**Lecture notes**
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

**Literature**
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

**Prerequisites / notice**
BIO142 Developmental Biology, BIO143 Neurobiology

### Chemical Biology and Synthetic Biochemistry
**Module Code:** 529-0733-02L
**Credits:** 6
**Lecturers:** K. Lang, M. Fottner

**Abstract**
Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.
Objective

After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.

Content

principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries)

advanced genetic code expansion methods (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing)

directed evolution and protein engineering

chemical biology of ubiquitin and targeted protein degradation

Lecture notes

A script will not be handed out. Handouts to the lecture will be provided through moodle.

Literature

Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Prerequisites / notice

Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies

Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Recommended Master Courses

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<tbody>
<tr>
<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>R. Taylor</td>
</tr>
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</table>

Abstract

This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

Objective

Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

Content

The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Students who attend this couc will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded.

Prerequisites / notice

Participants should be at a stage in their research where they can already start drafting parts of the report.

Elective Major: Molecular Health Sciences

Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

Recommended Master Courses

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<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, A. Hajnal, O. Voinnet, University lecturers</td>
</tr>
</tbody>
</table>

Abstract

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIC348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-special-students-university-of-zurich.html

Objective

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

This course focuses on the concepts of classical and modern genetics and genomics.
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Competencies

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Social Competencies

| Communication                                                     | fostered  |
| Cooperation and Teamwork                                          | fostered  |
| Self-presentation and Social Influence                            | fostered  |

Personal Competencies

| Creative Thinking                                                 | assessed   |
| Critical Thinking                                                  | fostered   |
| Self-awareness and Self-reflection                                 | fostered   |
| Self-direction and Self-management                                 | fostered   |

551-1299-00L Bioinformatics

Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Competencies

| Subject-specific Competencies                                      | assessed   |
| Concepts and Theories                                              |            |
| Techniques and Technologies                                        |            |
| Method-specific Competencies                                       | assessed   |
| Analytical Competencies                                            |            |
| Decision-making                                                   |            |
| Media and Digital Technologies                                     | assessed   |
| Problem-solving                                                   | assessed   |
| Project Management                                                 | fostered   |

Social Competencies

| Communication                                                     | fostered   |
| Cooperation and Teamwork                                          | fostered   |

Personal Competencies

| Adaptable and Flexibility                                         | fostered   |
| Creative Thinking                                                 | assessed   |
| Critical Thinking                                                  | assessed   |
| Integrity and Work Ethics                                          | fostered   |
| Self-awareness and Self-reflection                                 | fostered   |
| Self-direction and Self-management                                 | fostered   |

551-0317-00L Immunology I

Abstract
Introduction into structural and functional aspects of the immune system.
Basic knowledge of the mechanisms and the regulation of an immune response.

Objective
Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Competencies

| Subject-specific Competencies                                      | assessed   |
| Concepts and Theories                                              |            |
| Techniques and Technologies                                        |            |
| Method-specific Competencies                                       | fostered   |
| Analytical Competencies                                            | fostered   |
| Decision-making                                                   | fostered   |
| Problem-solving                                                   | fostered   |
| Project Management                                                 | fostered   |

Social Competencies

| Communication                                                     | fostered   |
| Cooperation and Teamwork                                          | fostered   |

Personal Competencies

| Adaptable and Flexibility                                         | fostered   |
| Creative Thinking                                                 | fostered   |
| Critical Thinking                                                  | assessed   |
| Self-awareness and Self-reflection                                 | fostered   |
| Self-direction and Self-management                                 | fostered   |
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course. Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

By the end of this module, each student should be able to:
- recognize the universal principles underlying the development of different animal body plans.
- explain how the genes encoding the molecular toolkit have evolved to create animal diversity.
- relate changes in gene structure or function to evolutionary changes in animal development.
- present and discuss a relevant evolutionary topic in an oral presentation
- select and integrate key concepts in animal evolution from primary literature
- participate in discussions on topics presented by others

The evolution of the various body-plans is investigated by means of comparison of developmentally essential control genes of molecularly analysed model organisms.

During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies. Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to evaluate, critically discuss and write about scientific articles in the research area of cellular biochemistry, and they will identify open testable research questions.

Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with frontal presentations. Guided by a faculty expert, students develop domain knowledge of the research area associated with a primary paper, and alternate as discussion leaders to present the research topic. By the end of the semester, students will formulate their ideas about open testable research questions that extend from the published work.

The literature will be provided during the course. The course will be taught in English.

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<tr>
<td>551-0571-00L</td>
<td>From DNA to Diversity: the Evolution of Multicellular Organisms (University of Zurich)</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. Hajnal, D. Bopp</td>
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<tr>
<td>551-1303-00L</td>
<td>Current Research Topics in Cellular Biochemistry</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>T. Kleele, V. Korkhov, G. Neurohr, V. Panse, M. Peter, A. E. Smith, F. van Drogen</td>
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<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>U. Sauer, N. Zamboni</td>
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</tbody>
</table>
**Abstract**

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

**Objective**

Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

**Content**

The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

**Lecture notes**

Script and original publications will be supplied during the course.

**Prerequisites / notice**

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

---

**551-1177-00L** Immunology: From Milestones to Current Topics  
**W 4 credits 2S**  
B. Ludewig, N. Pikor, University lecturers

**Abstract**

Milestones in Immunology: on old concepts and modern experiments

**Objective**

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

**Content**

Milestones and current topics of innate immunity, antigen presentation, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

**Lecture notes**

Original and review articles will be distributed by the respective lecturer.

**Literature**

Literaturunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

**Competencies**

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**752-4009-00L** Molecular Biology of Foodborne Pathogens  
**W 3 credits 2V**  
M. Loessner, A. Harms, M. Schuppler, E. Slack

**Abstract**

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

**Objective**

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

**Content**

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

**Lecture notes**

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

**Literature**

Lectures (2 hours) will be held as a single session of approximately 60 minutes (10:15 until approx. 11:15 h), without a break!

**Competencies**

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<td>Personal Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>fostered</td>
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<td>Critical Thinking</td>
<td>fostered</td>
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**376-0300-00L** Essentials in Translational Science  
**W 3 credits 2G**  
J. Goldhahn

**Abstract**

Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicines). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

**Objective**

After completing this course, students will be able to understand:

- Principles of translational science including medical device development, intellectual property, regulatory environment and project management
- Students should be able to apply this knowledge in drug development programs in Pharma, Biotech or their own spin-off.

**Content**

What is translational science and what is it not including:

- How to identify need?
- How to choose the appropriate research type and methodology
- How to measure success?
- How are medical devices developed?
- How to handle IP in the development process?
- How does the regulatory environment impact innovation?
- How to manage complex development projects?

- Positive and negative examples will be illustrated by distinguished guest speakers.
<table>
<thead>
<tr>
<th>Literature</th>
<th>Principles of Biomedical Sciences and Industry</th>
<th>Translating Ideas into Treatments</th>
<th><a href="https://doi.org/10.1002/9783527824014">https://doi.org/10.1002/9783527824014</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisites / notice</td>
<td>4x online input lecture followed by case preparation and symposium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
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<td>Techniques and Technologies</td>
<td>fostered</td>
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<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td>Decision-making</td>
<td>assessed</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Negotiation</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
</tr>
</tbody>
</table>

### 701-1703-00L Evolutionary Medicine for Infectious Diseases

| Objective | Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This requires incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses. |
| Content | We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (<5 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class. |
| Literature | The focus is on primary literature, but for some parts the following text books provide good background information:  
Schmid Hempel 2011 Evolutionary Parasitology  
Stearns & Medzhitov 2016 Evolutionary Medicine |

### 636-0108-00L Biological Engineering and Biotechnology

| Competencies | Subject-specific Competencies | Concepts and Theories | assessed |
| | | Techniques and Technologies | fostered |
| | Method-specific Competencies | Problem-solving | fostered |
| | Social Competencies | Communication | assessed |
| | Personal Competencies | Creative Thinking | fostered |
| | | Critical Thinking | assessed |

### 551-1407-00L RNA Biology Lecture Series I: Transcription & Processing & Translation

| Objective | The students should obtain an understanding of these processes, which are at work during gene expression. |
| Content | This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation. |
| Prerequisites / notice | Basic knowledge of cell and molecular biology. |

### 551-1409-00L RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

| Prerequisites / notice | Does not take place this semester. |
This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

Objective

The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

Content

Micro RNAs; computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; tRNA biology.


Prerequisites / notice

Basic knowledge of cell and molecular biology.

376-1305-00L Development of the Nervous System (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO344

Mind the enrolment deadlines at UZH:

Abstract

The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

Objective

On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills

On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system

Content

The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes

Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/

as BIO344

Literature

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice

BIO142 Developmental Biology, BIO143 Neurobiology

376-1305-01L Molecular Neurophysiology: From Molecules to Systems

Information for UZH students:
Enrolment to this course unit only possible at ETH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Abstract

The course covers the physiology of nerve cells, from the single cell through the neuronal network to the systemic level. The focus is on molecular and cellular mechanisms – synaptic transmission, signal transduction, gene expression, synaptic plasticity.

Objective

Based on an understanding of molecular and cellular mechanisms, the aim is to provide a deepened insight into neurophysiological processes underlying complex brain functions – learning/memory, sleep, sensory.

Content

First, basic molecular and cellular mechanisms in nerve cells (excitability, neurotransmission, signal transduction, gene expression, synaptic plasticity) are introduced. Afterwards, their significance for selected neurophysiological processes (learning/memory, sleep, sensory) will be illuminated.

Literature

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle.

Competencies

Subject-specific Competencies assessed
Concepts and Theories
Analytical Competencies

Method-specific Competencies

551-0223-00L Immunology III

Abstract

This course provides a detailed understanding of
- development of T and B cells
- the dynamics of a immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective

Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses, - Recognition of pathogenic microorganisms by the host cells and molecular events thereafter, - events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

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Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice
Immunology I and II recommended but not compulsory

Recommended Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0575-00L</td>
<td>Writing Scientific Reports for MSc Biology</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>R. Taylor</td>
</tr>
</tbody>
</table>

Abstract
This short course is designed to accompany MSc students in writing their first reports in English, providing input on scientific writing in English as well as feedback on drafts sections of the report.

Objective
Students will learn to:
- Plan, draft, structure, and edit scientific reports
- Produce reader-friendly sentences
- Establish a clear and logical flow between sentences and paragraphs
- Select formal vocabulary and use it in a generally accurate and correct manner
- Choose and use generally suitable grammatical structures, punctuation, and identify areas in which further development is needed

Content
The course covers the process of writing reports in biology, helping students to focus on the language and communicative aspects of these reports. Topics covered include structuring sentences, paragraphs, and longer sections (introductions, methods, etc.); presenting and integrating non-textual elements such as graphs and tables; reviewing common grammar problems for advanced writers in English; and editing drafts and proofs. Sessions will consist of a mix of specialist input, group and pair work, and editing sessions.

Students who attend this course will turn in three sections of a report (approx. 500 words each) for feedback, revising these texts for a final portfolio that is graded.

Prerequisites / notice
Participants should be at a stage in their research where they can already start drafting parts of the report.

Elective Major: Biochemistry

See Major in Biochemistry

Elective Major: Molecular Plant Biology

See Major in Molecular Plant Biology

Elective Major: Systems Biology

See Major in Systems Biology

Elective Major: Molecular and Structural Biology

See Major in Molecular and Structural Biology

Research Projects
Research projects neither accepted nor registered nor approved will not be credited.
Research Project I
Only for Biology Master, Programme Regulations 2018

Abstract
Research projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.

Research Project II
Only for Biology Master, Programme Regulations 2018

Abstract
Research projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.

Master's Thesis
A Master's thesis neither accepted nor registered nor approved will not be credited.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1800-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme;
- c. have acquired at least 30 credits in the category "research projects".

Abstract
The Master research will be carried out on a theme in the chosen subject area and must be completed with a written report (Thesis) within six months.

Master's Examination

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1800-01L</td>
<td>Master's Examination</td>
<td>O</td>
<td>4</td>
<td></td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are admitted for the master examination
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
In the Master’s examination a student must provide proof of general knowledge in the elective major field. Starting with a discussion based on the Master’s thesis further experiments and experimental strategies should be discussed in order to test the general understanding.

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BIOL

Biology Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Biomedical Engineering Master

Track Courses

Bioelectronics

Track Core Courses

During the Master programme, a minimum of 12 CP must be obtained from track core courses.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>T. Jang</td>
</tr>
<tr>
<td>227-0311-00L</td>
<td>Qubits, Electrons, Photons</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>T. Zambelli</td>
</tr>
</tbody>
</table>

Abstract

**Microrobotics**
- Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective
- The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
- Main topics of the course include:
  - Scaling laws at micro/nano scales
  - Electrostatics
  - Electromagnetism
  - Low Reynolds number flows
  - Observation tools
  - Materials and fabrication methods
  - Applications of biomedical microrobots

Lecture notes
- The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
- The lecture will be taught in English.

**Microsystems I: Process Technology and Integration**
- Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and devices by a sequence of defined processing steps (process flow).

Objective
- Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (process flow).

Content
- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties

Application of selected technologies will be demonstrated on case studies.

Lecture notes
- Lectures (available online)

Literature
- S. M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O. Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites / notice
- Prerequisites: Physics I and II

**Introduction to Estimation and Machine Learning**
- Students master the basic mathematical concepts and algorithms of estimation and machine learning.

Objective
- Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more.

Content
- Lecture notes will be handed out as the course progresses.

Lecture notes
- Lecture notes will be handed out as the course progresses.

Prerequisites / notice
- solid basics in linear algebra and probability theory

**Analog Integrated Circuits**
- This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

Objective
- Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

Content
- Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.
- The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes
- Handouts of presented slides. No script but an accompanying textbook is recommended.

Literature
Objective

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!).

Content

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM, while corresponding videos of the previous years are available in Moodle !!!

Literature


Supplementary material will be uploaded in Moodle.

Prerequisites / notice

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET "Physics II".

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

227-0385-10L Biomedical Imaging W 6 credits 5G S. Kozerke, K. P. Prüssmann

Abstract

Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective

Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications
Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.

Biomedical sensors both wearable and also biochemical sensors.

Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.

Bioinformatics: genomic and proteomic tools, databases and basic calculations.

Equations describing basic reactions and enzyme kinetics.

Medical optics: Optical components and systems used in hospitals.

Basic concepts of tissue engineering and organ printing.

Biomaterials and their medical applications.

Function of the heart and the circulatory system.

Transport and exchange of substances in the human body, compartment modeling.

The respiratory system.

Bioimaging.

Orthopedic biomechanics.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes

Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND

Prerequisites / notice

No specific requirements, BUT

ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Competencies Subject-specific Competencies

Techniques and Technologies assessed

Concepts and Theories assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making assessed

Media and Digital Technologies fostered

Problem-solving fostered

Project Management fostered

Social Competencies

Communication fostered

Cooperation and Teamwork fostered

Customer Orientation fostered

Leadership and Responsibility fostered

Self-presentation and Social Influence fostered

Sensitivity to Diversity fostered

Negotiation fostered

Personal Competencies

Adaptability and Flexibility fostered

Creative Thinking fostered

Critical Thinking fostered

Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered

Self-direction and Self-management fostered

Abstract

The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective

During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content

Lecture topics:
1. Introduction
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics
10. In vivo stimulation and recording
11. In vivo electrophysiology
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy
14. Measuring biochemical signals

Lecture notes

A detailed script is provided to each lecture including the exercises and their solutions.

Literature

Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice

The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
fostered Understanding of the characteristics of neuromorphic circuit elements.

Deep-Learning (DL) a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g., simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Understanding of the characteristics of neuromorphic circuit elements.
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

**227-1037-00L**  
Introduction to Neuroinformatics  
W 6 credits  
V. Mante, B. Grewe, G. Indiveri, M. Payvand

**376-1714-00L**  
Biocompatible Materials  
W 4 credits  
K. Maniura, M. Rottmar, M. Zenobi-Wong

Prerequisites: Particular: The course is highly recommended for those who intend to take the spring semester course 'Neuromorphic Engineering II', that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.
Objective
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

Recommended Elective Courses
These courses are particularly recommended for the Bioelectronics track. Please consult your track advisor if you wish to select other subjects.

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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Ahmed</td>
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<tr>
<td>Abstract</td>
<td>The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.</td>
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<tr>
<td>Objective</td>
<td>The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.</td>
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<td>Content</td>
<td>Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.</td>
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<td>Techniques and Technologies</td>
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<td>Media and Digital Technologies</td>
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<td>Negotiation</td>
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<td>Personal Competencies</td>
<td>Critical Thinking</td>
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<td>151-0905-00L</td>
<td>Medical Technology Innovation - From Concept to Clinics</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>I. Herrmann</td>
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<tr>
<td>Abstract</td>
<td>Project-oriented learning on how to develop technological solutions to address unmet clinical needs.</td>
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<tr>
<td>Objective</td>
<td>After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.</td>
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<td>Lecture notes</td>
<td>will be available on the moodle.</td>
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<td>Literature</td>
<td>will be available on the moodle.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>On site presence during (most) of the lectures highly encouraged! Graded innovation project will require on-site presence.</td>
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Competencies | Subject-specific Competencies | Concepts and Theories | assessed |
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<td>Creative Thinking</td>
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<td>Self-awareness and Self-reflection</td>
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<tr>
<th>151-0913-00L</th>
<th>Introduction to Photonics</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.</td>
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<tr>
<td>Objective</td>
<td>Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.</td>
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<td>Content</td>
<td><strong>I- BASICS OF WAVE THEORY</strong>&lt;br&gt;1) General concepts&lt;br&gt;2) Differential wave equation&lt;br&gt;3) Wavefront&lt;br&gt;4) Plane waves and Fourier decomposition of optical fields&lt;br&gt;5) Spherical waves and Huygens-Fresnel principle</td>
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<td><strong>II- ELECTROMAGNETIC WAVES</strong>&lt;br&gt;1) Maxwell equations&lt;br&gt;2) Wave equation for EM waves&lt;br&gt;3) Dielectric permittivity&lt;br&gt;4) Refractive index&lt;br&gt;5) Nonlinear optics&lt;br&gt;6) Polarisation and polarisation control</td>
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<td><strong>III- PROPAGATION OF LIGHT</strong>&lt;br&gt;1) Waves at an interface&lt;br&gt;2) The Fresnel coefficients&lt;br&gt;3) Total internal reflection&lt;br&gt;4) Evanescent waves&lt;br&gt;5) Dispersion diagram</td>
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<td><strong>IV- INTERFERENCES</strong>&lt;br&gt;1) General considerations&lt;br&gt;2) Temporal and spatial coherence&lt;br&gt;3) The Young double slit experiment&lt;br&gt;4) Diffraction gratings&lt;br&gt;5) The Michelson interferometer&lt;br&gt;6) Multi-wave interference&lt;br&gt;7) Antireflecting coating and interference filters&lt;br&gt;8) Optical holography</td>
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<td><strong>V- LIGHT MANIPULATION</strong>&lt;br&gt;1) Optical waveguides&lt;br&gt;2) Photonic crystals&lt;br&gt;3) Metamaterials and metasurfaces&lt;br&gt;4) Optical cavities</td>
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<td><strong>VI- OPTICAL FORCES AND OPTICAL TWEEZERS</strong>&lt;br&gt;1) History of optical forces&lt;br&gt;2) Theory of optical trapping&lt;br&gt;3) Atom cooling&lt;br&gt;4) Optomechanics&lt;br&gt;5) Applications of optical tweezers</td>
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<td><strong>VII- INTRODUCTION TO OPTICAL MICROSCOPY</strong>&lt;br&gt;1) Basic concepts&lt;br&gt;2) Direct and Fourier imaging&lt;br&gt;3) Image formation&lt;br&gt;4) Fluorescence microscopy&lt;br&gt;5) Scattering-based microscopy&lt;br&gt;6) Digital holography&lt;br&gt;7) Computational imaging</td>
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Molecular Sensors: From Fundamentals to Health and Environmental Applications

Note: previous course title until HS23 "Molecular Health Sensors and Devices"

Molecular sensors are used in everyday life in health care, environmental monitoring, food safety, space and other fields. Sources of molecular information, its transport and fundamental concepts of molecular sensing will be discussed. In the scope of group projects, the acquired knowledge will be applied and deepened in case studies.

After the course, the students will:

- know the requirements and merits of molecular sensors for health, environmental and other emerging applications (e.g. space)
- understand transport phenomena of molecular information & surface interactions and know how to quantitatively describe these
- understand fundamental sensing concepts for the detection and quantification of molecular analytes
- know concepts of signal processing
- be capable to apply the learnt knowledge to conceive and engineer sensor concepts and systems
- know how to investigate sensor-related literature and present scientific data

This course consists of a theoretical and a project-based learning block. In the first 10 semester weeks, theoretical knowledge will be provided through lectures and deepened in corresponding exercises. In the last 4 weeks, the students will apply the learned concepts through group projects to investigate case studies. The outcome will be present.

Transport of Molecular Information; Surface Interactions; Sensor Fundamentals; Chemoresistive Sensing; Electrochemical Sensing; Mass-sensitive; Capacitive Sensing; Signal Processing; Medical Requirements for Molecular Sensing

Hand-outs will be provided to each lecture including the exercises and their solutions.

Neuromorphic Engineering I

Registration in this class requires the permission of the instructor. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.
Prerequisites: Background in basics of semiconductor physics helpful, but not required.

## 227-1051-00L Systems Neuroscience (University of Zurich)

**W** 6 credits 2V+1U  D. Kiper

*No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.*

**UZH Module Code:** INI415

### Abstract

This course focuses on basic aspects of central nervous system physiology, including perception, motor control and cognitive functions.

### Objective

To understand the basic concepts underlying perceptual, motor and cognitive functions.

### Content

Main emphasis sensory systems, with complements on motor and cognitive functions.

### Literature

None

### Prerequisites / notice

None

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## 227-0384-00L Ultrasound Fundamentals and Applications in Biology and Medicine

**W** 4 credits 3G  X. L. Dean Ben

*Previously (up to spring 2020) offered as Ultrasound Fundamentals, Imaging, and Medical Applications*

### Abstract

Ultrasound waves are non-ionizing and thus provide a safe means to interrogate and treat biological tissues. Advantages such as real-time operation, low cost, and portability have led to ultrasound systems becoming standard tools in hospitals and research laboratories. In biology and medicine include ultrasound and optoacoustic imaging, thermal therapy, or pulse stimulation.

### Objective

The objective of the course is that students are able to understand how to use ultrasound in biology and medicine and generalize this knowledge to applications in other fields.

### Content

The course will cover the basic physics of ultrasound (acoustic waves at frequencies higher than the audible range) in biological tissues as well as the instrumentation required to generate and detect these waves. Imaging methods will extensively be described in the course. Specifically, standard and ultra-fast ultrasound imaging approaches will be covered along with newer optoacoustic and transmission ultrasound imaging methods. The course will also describe mathematical modeling approaches and numerical methods as well as signal and image processing tools applicable in ultrasound-based imaging. Other topics include ultrasound sensors, laser ultrasound, therapeutic effects, or biomedical applications and contrast agents. The course will conclude with current and future research directions in the field of ultrasound in biomedicine.

### Lecture notes

The lecture slides will be made available to the students.

### Prerequisites / notice

Basic knowledge in physics. Basic programming skills, preferably in Matlab.

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## 227-0166-00L Analog Integrated Circuits

**W** 6 credits 4G  T. Jang

### Abstract

This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

### Objective

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

### Content

Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

### Lecture notes

Handouts of presented slides. No script but an accompanying textbook is recommended.

### Literature


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## 227-0447-00L Image Analysis and Computer Vision

**W** 6 credits 3V+1U  E. Konukoglu, E. Erdil, F. Yu

### Abstract


### Objective

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

### Content

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

### Lecture notes

Course material Script, computer demonstrations, exercises and problem solutions

### Prerequisites / notice

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

### Language

The course language is English.

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## 227-0468-00L Analog Signal Processing and Filtering

**W** 6 credits 2V+2U  H. Schmid

*Suitable for Master Students as well as Doctoral Students.*
This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites / notice

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria …) and of the main properties of linear systems is necessary.

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

This course focuses on the current state and prospects of memory technologies, emerging beyond the silicon transistor era. We explore resistive PCM and RRAM, magnetic MRAM and ferroelectric FRAM memories, covering physics, device aspects and the latest research in the field. Through interactive lectures and laboratory sessions, students gain up-to-date knowledge and compare emerging memory techs.

This course is organized as a series of lectures, focusing on selected memory technologies. This class also includes practical laboratory sessions for the PCM research topics. Students will spend 2 hours per week in the class and laboratory and additional 2-3 hours per week to prepare for the exam.

Lecture notes

Lecture notes will be made available on the website.
The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since cross-disciplinary collaboration between engineers and medical doctors is indispensable for innovation in health care. This course brings together engineering students from ETH Zurich and medical students from the University of Zurich to experience the rewards and challenges of such interdisciplinary work in a project based learning environment.

**Objective**
The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since such differences become most evident during actual collaborative work, the course is based on a project in physiology, medical or clinical research that combines medicine and engineering.

For the engineering students, the specific aims of the course are to:
- Identify and precisely define a clinical need;
- Acquire a working understanding of the investigated system;
- Identify the engineering challenges in the project and communicate them to the medical students;
- Develop and implement, together with the medical students, solution strategies for the identified challenges;
- Present the solution concept to a cross-disciplinary audience; Preliminary need and solution validation;

Content
After a general introduction to interdisciplinary communication, need identification and product development, the engineering students will team up with medical students to 1) identify a clinically relevant need, 2) develop early-stage solution concepts to it. In the process, they will be supervised both by lecturers from ETH Zurich and the University of Zurich, receiving coaching customized to the project. The project is usually defined by the team itself, but can also be guided by the lecturers. The course will end with each team presenting identified need and solution concept to a cross-disciplinary audience.

**Lecture notes**
Lecture handouts and relevant material will be provided.

**Prerequisites / notice**
IMPORTANT: Note that a special permission from the lecturers is required to register for this course. Contact the head lecturer to that end.

**Competencies**

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<thead>
<tr>
<th>Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<tbody>
<tr>
<td><strong>Cross-Disciplinary Research and Development in Medicine and Engineering</strong></td>
<td>Analytical Competencies</td>
<td>Communication</td>
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<tr>
<td><strong>W 4 credits</strong></td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
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<tr>
<td><strong>227-0981-00L</strong></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
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<td><strong>Theory and corresponding exercises are merged together during the classes.</strong></td>
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<td>Negotiation</td>
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<tr>
<td><strong>Cell Biophysics</strong></td>
<td>Creative Thinking</td>
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<td><strong>W 6 credits</strong></td>
<td>Critical Thinking</td>
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<td><strong>227-0939-00L</strong></td>
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<td><strong>Critical Thinking</strong></td>
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**Content**

- Applicating two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

**Objective**

**Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.**

**Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.**

**Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature.**

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

**Theory and corresponding exercises are merged together during the classes.**

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Lecture notes
No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o'clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!

Literature

As further deepening:

Prerequisites / notice
Participants need a good command of
• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Competencies

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<td>Techniques and Technologies</td>
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Social Competencies
Communication | tested |
Cooperation and Teamwork | tested |
Customer Orientation | tested |
Leadership and Responsibility | tested |
Self-presentation and Social Influence | tested |
Sensitivity to Diversity | assessed |
Negotiation | tested |

Personal Competencies
Adaptability and Flexibility | assessed |
Creative Thinking | assessed |
Critical Thinking | assessed |
Integrity and Work Ethics | assessed |
Self-awareness and Self-reflection | assessed |
Self-direction and Self-management | assessed |

227-0976-00L Computational Psychiatry & Computational Psychosomatics
2 credits
4S K. Stephan

Abstract
This seminar deals with the development of clinically relevant computational tools and/or their application to psychiatry and psychosomatics. It is complementary to the annual Computational Psychiatry Course and serves to build bridges between computational scientists and clinicians. It is designed to foster in-depth exchange, with ample time for discussion.

Objective
Understanding strengths and weaknesses of current trends in the development of clinically relevant computational tools and their application to problems in psychiatry and psychosomatics.

Content
This seminar deals with the development of computational tools (e.g. generative models, machine learning) and/or their application to psychiatry and psychosomatics. The seminar includes (i) presentations by computational scientists and clinicians, (ii) group discussion with focus on methodology and clinical utility, (iii) self-study based on literature provided by presenters.

Literature
Literature for additional self-study of the topics presented in this seminar will be provided by the presenters and will be available online at https://www.tnu.ethz.ch/en/teaching

Prerequisites / notice
Participants are expected to be familiar with general principles of statistics (including Bayesian statistics) and have successfully completed the course “Computational Psychiatry” (Course number 227-0971-00L).

227-2037-00L Physical Modelling and Simulation
6 credits
4G J. Smajic

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

263-3210-00L Deep Learning

Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://mi2.in.tum.de/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://mi2.in.tum.de/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-118

263-5702-00L Seminar on Digital Humans

Objective
This seminar covers advanced topics in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

Prerequisites / notice
This seminar covers advanced topic in digital humans including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All students read the papers and participate in the discussion.

Content
The seminar covers advanced topics in digital humans including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All students read the papers and participate in the discussion.

263-5902-00L Computer Vision

Objective
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Content
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

376-1103-00L Frontiers in Nanotechnology

Abstract
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

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Objective

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

376-1176-00L  

**Wearable and Mobile Technologies of the Future - Focus on Sports and Health**

**Abstract**

This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

**Objective**

Objective 1: Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2: Acquire skills to design novel non-invasive technologies for sport and health.

**Content**

The course consists of two modules.

Module 1: Movement.

This module provides the scientific background needed to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies.

Module 2: Cardiac.

This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies and the latest data analysis techniques to monitor the cardiac cycle for assisting individuals in sport activities or monitoring their health conditions.

**Prerequisites / notice**

- Students should be proficient in programming (any language).
- Note: assignments will be in MATLAB. Students are expected to learn MATLAB on their own if not experienced with this programming language.
- Course prerequisites:
  - For Biomedical Engineering Master's: none
  - For ITET Master's: none
  - For D-MAVT Master's: none
  - For D-HEST Master's and PhD students:
    - • If BSc in electrical/mechanical engineering or computer science: none
    - • If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)

376-1219-00L  

**Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions**

**Abstract**

Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

**Objective**

Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Content

Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature

Introductory Books:


Selected Journal Articles and Web Links:

Prerequisites / notice

Target Group:
- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidics is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- 2 × 45 min will be covered by Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, who will present how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.
Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, 'soft' lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small scale Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

Lecture notes
Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

Literature
There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

Literature
Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

Abstract
Lecture notes

Biology Courses

Number Title Type ECTS Hours Lecturers
227-0399-10L Physiology and Anatomy for Biomedical Engineers I W 3 credits 2G M. Wyss
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Ultrasound waves are non-ionizing and thus provide a safe means to interrogate and treat biological tissues. Advantages such as real-time assessment make ultrasound well suited for applications including: ultrasound and optoacoustic imaging, thermal therapy, or pulse stimulation.

### Bioimaging

#### Track Core Courses

During the Master programme, a minimum of 12 CP must be obtained from track core courses.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0384-00L</td>
<td>Ultrasound Fundamentals and Applications in Biology and Medicine</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>X. L. Dean Ben</td>
</tr>
<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüssmann</td>
</tr>
</tbody>
</table>

#### Prerequisites / notice
- Basic knowledge in physics. Basic programming skills, preferably in Matlab.
- The lecture slides will be made available to the students.
- The course is offered in the Autumn Semester 2024.

#### Content
- Previous offerings:
  - Medical Imaging: Ultrasound (spatial and temporal resolution, phased arrays)
  - Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
  - Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
  - Biomedical Imaging: Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
  - Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
  - Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Biomedical Imaging: X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- Biomedical Imaging: X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Biomedical Imaging: Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
- Biomedical Imaging: Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Biomedical Imaging: Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Biomedical Imaging: Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Biomedical Imaging: Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Biomedical Imaging: Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Biomedical Imaging: Ultrasound (spatial and temporal resolution, phased arrays)
- Biomedical Imaging: Ultrasound (Doppler shift, implementations, applications)
- Biomedical Imaging: Summary, example exam questions
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

Prerequisites

Notices

Methods

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Method-specific Competencies

Social Competencies

Communication

Personal Competencies

Cooperation and Teamwork

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-direction and Self-management

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Methods

Communication

Personal Competencies

Cooperation and Teamwork

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-direction and Self-management

Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.

Biomedical sensors both wearable and also biochemical sensors.

Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.

Bioinformatics: genomic and proteomic tools, databases and basic calculations.

Equations describing basic reactions and enzyme kinetics.

Medical optics: Optical components and systems used in hospitals.

Basic concepts of tissue engineering and organ printing.

Biomaterials and their medical applications.

Function of the heart and the circulatory system.

Transport and exchange of substances in the human body, compartment modeling.

The respiratory system.

Bioimaging.

Orthopedic biomechanics.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes

Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

Prerequisites / notice

No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Method-specific Competencies

Project Management

Social Competencies

Communication

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Abstract


Objective

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

### Lecture notes
- **Course material Script**, computer demonstrations, exercises and problem solutions
- Prerequisites:
  - Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
- The course language is English.

#### 227-0965-00L Micro and Nano-Tomography of Biological Tissues

**W** 4 credits 3G M. Stampanoni, F. Marone Welford

**Abstract**
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

**Objective**
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

**Content**
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

**Lecture notes**
Available online

**Literature**
Will be indicated during the lecture.

#### Recommended Elective Courses
These courses are particularly recommended for the Bioimaging track. Please consult your track advisor if you wish to select other subjects.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0311-00L</td>
<td>Qubits, Electrons, Photons</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>T. Zambelli</td>
</tr>
</tbody>
</table>

**Abstract**
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

**Objective**
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

**Content**
- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

**Lecture notes**
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

**Literature**

Supplementary material will be uploaded in Moodle.

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+ (as rigorous and profound presentation of the mathematical framework) G. Dell'Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer
+ (as account of those formidable years) G. Gamow, "Thirty Years that Shook Physics", 1985, Dover Publications Inc.
The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce Deep-learning, a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

This seminar teaches problem solving skills for computational neuroimaging, based on analyses of neuroimaging and behavioural data. It fosters subject-specific competencies.

Computational Neuroimaging Clinic fosters subject-specific competencies.

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET "Physics II".

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
<th>The course notes</th>
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</thead>
<tbody>
<tr>
<td><strong>Learning in Deep Artificial and Biological Neuronal Networks</strong> 227-0421-00L</td>
<td>W 4 credits 3G</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience.</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>The lecture slides will be provided as a PDF after each lecture.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial on Deep networks in PyTorch or Tensorflow, although these tools are used.</td>
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<td><strong>Adaptability and Flexibility</strong> Personal Competencies</td>
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</table>

227-0967-00L Computational Neuroimaging Clinic W 3 credits 2V K. Stephan

| **Prerequisite: Successful completion of course "Methods & Models for fMRI Data Analysis", "Translational Neuroimaging", "Computational Psychology"** Abstract | This seminar teaches problem solving skills for computational neuroimaging, based on analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g. mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data. |
| **Objective** | 1. Consolidation of theoretical knowledge (obtained in the following courses: "Methods & models for fMRI data analysis", "Translational Neuroimaging", "Computational Psychology") in the setting of concrete research questions. 2. Acquisition of practical problem solving strategies for computational modeling of neuroimaging data. |
| **Content** | This seminar teaches problem solving skills for computational neuroimaging, based on analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g. mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data. |

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 393 of 2667
Methods & Models for fMRI Data Analysis

**Abstract**

This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), including preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

**Objective**

To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

**Content**

This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), including preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

---

Neuromorphic Engineering I

**Abstract**

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective**

Understanding the characteristics of neuromorphic circuit elements.

**Content**

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuit elements, from elementary devices to systems.

---

Introduction to Neuroinformatics

**Abstract**

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

---

Prerequisites / notice

The participants are expected to have successfully completed at least one of the following courses:

- 'Methods & models for fMRI data analysis',
- 'Translational Neumorodelling',
- 'Computational Psychiatry'

**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Creative Thinking

**Content**

- 227-0969-00L Methods & Models for fMRI Data Analysis
  - W 6 credits 4V 227-0971-00L Computational Psychiatry
  - W 3 credits 4S
  - W 6 credits 2V+3U
  - 227-1033-00L Neuromorphic Engineering I
  - W 6 credits 2V+1U+1A
  - 227-1037-00L Introduction to Neuroinformatics
  - W 6 credits 2V+1U+1A
Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to offering solutions.

Content
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

227-2037-00L Physical Modelling and Simulation

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. In the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or choose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

252-0543-01L Computer Graphics

Abstract
This course covers fundamental and advanced concepts of modern computer graphics. Students will learn the fundamentals of digital scene representations, advanced physically-based light transport algorithms for generating photorealistic images from these scene representations, and inverse rendering methods for recovering digital scene representations from captured images.

Objective
At the end of the course, the students will be able to build a rendering system based on path-tracing algorithms. The students will learn the principles of physically-based rendering and computer graphics. In addition, the course is intended to stimulate the student's curiosity to explore the field of computer graphics in subsequent classes or on their own.

Content
We will begin with an introduction to light emission and radiometric quantities, followed by an exploration of geometry representations and texture mapping. Next, we will mathematically formulate the physics of light transport and appearance modeling. Subsequently, we will introduce relevant concepts from Monte Carlo integration and develop path-tracing algorithms to solve these equations by simulating light transport for direct and global illumination due to hard surfaces and participating media, such as fog, smoke, and translucent objects. Moreover, we will present techniques for significantly improving path-tracing efficiency, including importance sampling, multiple importance sampling, stratified sampling, denoising, and acceleration data structures. The course lectures will conclude with an overview of image-based capture and rendering methods. Topics covered will include geometry reconstruction, material acquisition, differentiable rendering, and image-based rendering.

Lecture notes
no

Literature
Books:
- Physically Based Rendering: From Theory to Implementation
- High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
- Multiple view geometry in Computer Vision

Prerequisites / notice
Prerequisites:
Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, and the Visual Computing course are recommended.
The programming assignments will be in C++. This will not be taught in the class.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork assessed
- Leadership and Responsibility fostered

Personal Competencies
- Creative Thinking assessed
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-direction and Self-management fostered

402-0674-00L Physics in Medical Research: From Atoms to Cells

Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epithelial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
Objective

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructures shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultraviolet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>465-0953-00L</td>
<td>Biostatistics</td>
<td>W</td>
<td>4</td>
<td></td>
<td>B. Sick</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests, measurement of agreement, causality versus association.</td>
<td></td>
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</tbody>
</table>
| Objective  | - know the commonly used methods in biostatistics  
- perform simple data analysis with R |
| 227-0976-00L | Computational Psychiatry & Computational Psychosomatics | W    | 2    | 4S    | K. Stephan |
| Abstract   | This seminar deals with the development of clinically relevant computational tools and/or their application to psychiatry and psychosomatics. It is complementary to the annual Computational Psychiatry Course and serves to build bridges between computational scientists and clinicians. It is designed to foster in-depth exchange, with ample time for discussion. |
| Objective  | Understanding strengths and weaknesses of current trends in the development of clinically relevant computational tools and their application to problems in psychiatry and psychosomatics. |
| Content    | This seminar deals with the development of computational tools (e.g. generative models, machine learning) and/or their application to psychiatry and psychosomatics. The seminar includes (i) presentations by computational scientists and clinicians, (ii) group discussion with focus on methodology and clinical utility, (iii) self-study based on literature provided by presenters. |
| Literature | Literature for additional self-study of the topics presented in this seminar will be provided by the presenters and will be available online at https://www.tnu.ethz.ch/en/teaching |
| Prerequisites / notice | Participants are expected to be familiar with general principles of statistics (including Bayesian statistics) and have successfully completed the course "Computational Psychiatry" (Course number 227-0971-00L). |

>>>> Biology Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0999-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3</td>
<td></td>
<td>M. Wyss</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3d animation database/software to use 'anatomical language' to retrieve anatomical structures to understand basic medical terminology</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
| Content    | - The Human Body: nomenclature, orientations, tissues  
- Musculoskeletal system, Muscle contraction  
- Blood vessels, Heart, Circulation  
- Blood, Immune system  
- Respiratory system  
- Acid-Base-Homeostasis |
| Lecture notes | Lecture notes and handouts |
| Literature | Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008  
Fallen A., Schuenke M. The Human Body; Thieme 2004  
Netter F. Atlas of human anatomy; Elsevier 2014 |
Upon completion of the course students are able to:

- Foster knowledge and understanding of concepts and theories related to cell and molecular biology.
- Apply laboratory skills and safety practices in cell culture and molecular biology experiments.
- Conduct experiments using basic techniques of cell and molecular biology.

The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology. It covers essential laboratory skills and safety, cell culture, protein analysis, RNA/DNA isolation, and related procedures. Students will gain hands-on experience in these fundamental areas.

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<tr>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>S. Kozerke, M. P. Prüssmann</td>
</tr>
</tbody>
</table>

### Abstract

Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

### Objective

Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems.
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function.
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction.
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications.

### Content

- **Introduction** (intro, overview, history)
- **Signal theory and processing** (foundations, transforms, filtering, signal-to-noise ratio)
- **X-rays** (production, tissue interaction, contrast, modular transfer function)
- **X-rays** (resolution, detection, digital subtraction angiography, Radon transform)
- **X-rays** (filtered back-projection, spiral computed tomography, image quality, dose)
- **Nuclear imaging** (radioactive tracer, collimation, point spread function, SPE/C/PE/ET)
- **Nuclear imaging** (detection principles, image reconstruction, kinetic modelling)
- **Magnetic Resonance** (magnetic moment, spin transitions, excitation, relaxation, detection)
- **Magnetic Resonance** (plane wave encoding, Fourier reconstruction, pulse sequences)
- **Magnetic Resonance** (contrast mechanisms, gradient- and spin-echo, applications)
- **Ultrasound** (mechanical wave generation, propagation in tissue, reflection, transmission)
- **Ultrasound** (spatial and temporal resolution, phased arrays)
- **Ultrasound** (Doppler shift, implementations, applications)
- **Summary, example exam questions**

### Lecture notes

Lecture notes and handouts

### Literature

Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

### Prerequisites / notice

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

### Competencies

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
- **Social Competencies**
  - Communication
  - Cooperation and Teamwork
- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics

### Biomechanics

### Track Core Courses

**During the Master programme, a minimum of 12 CP must be obtained from track core courses.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

### Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. Focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

### Objective

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.
Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optimal components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.

Lecture notes

Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice

No specific requirements, BUT
ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

227-0447-00L  Image Analysis and Computer Vision  W  6 credits  E. Konukoglu, E. Erdil, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.
The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.
The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

227-0965-00L  Micro and Nano-Tomography of Biological Tissues  W  4 credits  M. Stampanoni, F. Marone Welford

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.
The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

The learning objectives include:
1. advanced knowledge of the state-of-the-are in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programing skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis. To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUEs). All videos and animations will be incorporated in Moodle and PolBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUEs: Tiny, Open-with-Restrictions courses focused on QUality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A). Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

Lecture notes:
Material will be provided on Moodle and eColab.

Prerequisites / notice:
Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

Competencies:
- Subject-specific Competencies:
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- Method-specific Competencies:
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: assessed

- Social Competencies:
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: fostered

- Personal Competencies:
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered
Objective
Introduction to the basic principles of trauma biomechanics.

Content
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

Lecture notes
Handouts will be made available.

Literature

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
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- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Recommended Elective Courses
These courses are particularly recommended for the Biomechanics track. Please consult your track advisor if you wish to select other subjects.

Number    Title                                  Type    ECTS    Hours    Lecturers
151-0524-00L    Continuum Mechanics I                    W    4 credits    2V+1U    A. E. Ehret
Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective
After successful completion of the course students are able to
- explain basic theories for solving continuum mechanics problems
- proficiently apply these theories by solving application-related academic examples
- relate the theories and examples to real engineering applications and challenges
- distinguish between different mechanical behaviors of materials
- systematically select appropriate constitutive theories suitable to analyze and model these materials

Content
Anisotropic Elasticity, Linear Elastic and Linear Viscous Material Behavior, Viscoelasticity, Micro-Macro Modelling, Laminate Theory, Plasticity, Viscoplasticity, Examples of Engineering Applications, Comparison with Experiments

Lecture notes
yes

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

151-0604-00L    Microrobotics                               W    4 credits    3G    B. Nelson
Abstract
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

151-0905-00L    Medical Technology Innovation - From Concept to Clinics   W    4 credits    3G    I. Herrmann
Abstract
Project-oriented learning on how to develop technological solutions to address unmet clinical needs.
Objective
After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

Lecture Notes
will be available on the moodle.

Literature
will be available on the moodle.

Prerequisites / Notice
On site presence during (most) of the lectures highly encouraged!

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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<td>Problem-solving</td>
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<td></td>
<td>Project Management</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
<td>Self-awareness and Self-reflection</td>
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<td></td>
<td></td>
<td>Sensitivity to Diversity</td>
<td>Self-direction and Self-management</td>
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</table>

Graded innovation project will require on-site presence.

227-0384-00L Ultrasound Fundamentals and Applications in Biology and Medicine W 4 credits 3G X. L. Dean Ben

Abstract
Ultrasound waves are non-ionizing and thus provide a safe means to interrogate and treat biological tissues. Advantages such as real-time operation, low cost, and portability have led to ultrasound systems becoming standard tools in hospitals and research laboratories. Applications in biology and medicine include ultrasound and optoacoustic imaging, thermal therapy, or pulse stimulation.

Objective
The objective of the course is that students are able to understand how to use ultrasound in biology and medicine and generalize this knowledge to applications in other fields.

Content
The course will cover the basic physics of ultrasound (acoustic waves at frequencies higher than the audible range) in biological tissues as well as the instrumentation required to generate and detect these waves. Imaging methods will extensively be described in the course. Specifically, standard and ultra-fast ultrasound imaging approaches will be covered along with new optoacoustic and transmission ultrasound imaging methods. The course will also describe mathematical modelling approaches and numerical methods as well as signal and image processing tools applicable in ultrasound-based imaging. Other topics include ultrasound sensors, laser ultrasound, therapeutic effects, or biomedical applications and contrast agents. The course will conclude with current and future research directions in the field of ultrasound in biomedicine.

Lecture Notes
The lecture slides will be made available to the students.

Prerequisites / Notice
Basic knowledge in physics. Basic programming skills, preferably in Matlab.

263-5702-00L Seminar on Digital Humans W 2 credits 2S M. Gross, B. Solenthaler, O. Sorkine Hornung, S. Tang, R. Wampfler

Abstract
The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Objective
The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills.

Content
This seminar covers advanced topic in digital humans including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

Literature
Individual research papers are selected each term. See https://vlg.inf.ethz.ch/, https://igl.ethz.ch/, and http://graphics.ethz.ch/ for example papers.

Competencies

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
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</table>

Graded innovation project will require on-site presence.

376-1103-00L Frontiers in Nanotechnology W 4 credits 4V V. Vogel, further lecturers

Abstract
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.
Objective

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

376-1176-00L Wearable and Mobile Technologies of the Future - Focus on Sports and Health

Objective

Objective 1:
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2:
Acquire skills to design novel non-invasive technologies for sport and health.

Content

The course consists of two modules.

Module 1: Movement.
This module provides the scientific background needed to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies.

Module 2: Cardiac.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies and the latest data analysis techniques to monitor the cardiac cycle for assisting individuals in sport activities or monitoring their health conditions.

Prerequisites / notice

- Students should be proficient in programming (any language);
- Note: assignments will be in MATLAB. Students are expected to learn MATLAB on their own if not experienced with this programming language.
- Course prerequisites:
  - For Biomedical Engineering Master’s: none
  - For ITET Master’s: none
  - For D-NAV Master’s: none
  - For D-HEST Master’s and PhD students:
    - If BSc in electrical/mechanical engineering or computer science: none
    - If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

Objective

Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Content

Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
  - Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
  - Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
  - Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature

Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice

Target Group:
- Students of higher semesters and PhD students of
  - D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
Students of other departments, faculties, courses are also welcome
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
376-1220-00L Rehabilitation and Inclusion

Abstract
This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

Objective
With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenar discussions.

Content
The course will cover the following topics:
- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prostheses, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Parasports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention

376-1351-00L Micro/Nanotechnology and Microfluidics for Biomedical Applications

Abstract
This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Objective
The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.
Content

Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photons, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- 2 × 45 min will be covered by Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, who will present how to make 25$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Techniques and Technologies</th>
<th>Communication</th>
<th>Critical Thinking</th>
<th>Integrity and Work Ethics</th>
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<tr>
<td>Concepts and Theories</td>
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Abstract

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective

The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes

Handouts are deposited online (moodle).

Literature


(available online via ETH library)

Handouts and references therein.

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Data: 02.07.2024 12:39 Autumn Semester 2024 Page 405 of 2667
Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

This lectures introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.

Handouts will be made available.

Abstract
Current topics in biomechanics presented by speakers from academia and industry.

Objective
Getting insight into actual areas and problems of biomechanics.

Abstract
Biomechanics of Sports Injuries and Rehabilitation

Objective
This lecture introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries.

Content
This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented.

Lecture notes
Handouts will be made available.

Literature

Prerequisites / notice
A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

Abstract
Physics in Medical Research: From Atoms to Cells

Objective
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

Content
As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and

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Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s anisotropies of biopsies.

Abstract
Biostatistics

Objective
The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests, measurement of agreement, causality versus association.

- know the commonly used methods in biostatistics
- perform simple data analysis with R

Biology Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
</tbody>
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Objective
To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

Content
- The Human Body: nomenclature, orientations, tissues
- Musculoskeletal system, Muscle contraction
- Blood vessels, Heart, Circulation
- Blood, Immune system
- Respiratory system
- Acid-Base-Homeostasis

Lecture notes
Lecture notes and handouts

Literature
Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008
Faller A., Schuenke M. The Human Body; Thieme 2004
Netter F. Atlas of human anatomy; Elsevier 2014

227-0949-00L  Biological Methods for Engineers  W  3 credits  5P  C. Frei

Abstract
The course during 8 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA Isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory.

Objective
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Content
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Prerequisites / notice
Enrollment is limited and students from the Master's programme in Biomedical Engineering (BME) have priority.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered

Medical Physics

Track Core Courses
During the Master programme, a minimum of 12 CP must be obtained from track core courses.

Number  Title                      Type  ECTS  Hours  Lecturers
227-0311-00L  Qubits, Electrons, Photons  W  6 credits  3V+2U  T. Zambelli

Abstract
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Content
- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

IMPORTANT: “qubits” from the point of view of NMR (and NOT from that of quantum computing!).

In this way, students will work out a robust quantum mechanics (theoretical!!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

Supplementary material will be uploaded in Moodle.

Autumn Semester 2024
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

### Competencies

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

**Social Competencies**

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

### Content

- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PECT)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Summary, example exam questions

### Objective

Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

### Literature

Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

### Prerequisites / notice

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

### Social Competencies

- Communication: assessed
- Cooperation and Teamwork: assessed

### Personal Competencies

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

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<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüssmann</td>
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<tr>
<td>227-0943-00L</td>
<td>Radiobiology</td>
<td>W</td>
<td>2</td>
<td>2V</td>
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**Abstract**

Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

**By the end of this course the participants will be able to:**

a) interpret the 6 Rs of radiation oncology in the context of the hallmarks of cancer
b) understand factors which underpin the differing radiosensitivities of different tumors
c) follow rational strategies for combined treatment modalities of ionizing radiation with targeted and immunological agents
d) understand differences in the radiation response of normal tissue versus tumor tissue
e) understand different treatment responses of the tumor and the normal tissue to differential clinical-related parameters of radiotherapy (dose rate, LET etc.).
**Content**

Einführung in die Strahlenbiologie ionisierender Strahlen: Allgemeine Grundlagen und Begriffsbestimmungen; Mechanismen der biologischen Strahlenwirkung; Strahlenwirkung auf Zellen. Gewebe und Organe; Modifikation der biologischen Strahlenwirkung; Strahlenzytogenetik; Chromosomenveränderungen, DNA-Defekte, Reparaturprozesse; Molekulare Strahlenbiologie: Bedeutung inter- und intrazellulärer Signalübermittlungsprozesse, Strahlen-induzierter Zelltoth, Zellzyklus-Checkpoints; Radioimmunologie, Strahlenrisiko; Strahleninduzierte Krebsneubildungen, Mutationen, daraus resultierende Strahlenschutz; Nutzen-Risiko-Abwägungen bei der medizinischen Strahlenanwendung; Prädiktive strahlenbiologische Methoden zur Optimierung der therapeutischen Strahlenanwendung.

**Lecture notes**

Beilagen mit zusammenfassenden Texten, Tabellen, Bild- und Grafikdarstellungen werden abgegeben.

**Literature**

Literaturliste wird abgegeben.


Basic Clinical Radiobiology, edited by Joiner, van der Kogel, 2018

**Prerequisites / notice**

The former number of this course unit is 465-0951-00L.

**Competencies**

Subject-specific Competencies

Concepts and Theories

Assessed

Analytical Competencies

Assessed

402-0341-00L | Medical Physics I | W | 6 credits | 2V+1U | P. Manser

**Abstract**

Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiologically and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and illustration by means of Monte Carlo simulations.

**Objective**

Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefit of patients and society.

**Content**

The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

**Lecture notes**

A script will be provided.

**Prerequisites / notice**

For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

**Competencies**

Subject-specific Competencies

Concepts and Theories

Assessed

Techniques and Technologies

Assessed

402-0674-00L | Physics in Medical Research: From Atoms to Cells | W | 6 credits | 2V+1U | B. K. R. Müller

**Abstract**

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

**Objective**

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure’s shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichromism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimizing the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

R x-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s anisotropies of biopsies.

227-0941-00L | Physics and Mathematics of Radiotherapy Planning (University of Zurich) | W | 6 credits | 3G | University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: PHY471

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract
This lecture will provide a detailed introduction to radiotherapy treatment planning. The course considers the physical interactions of radiation in tissue, the mathematical aspects of treatment planning and additional aspects of central importance for radiotherapy planning.

Objective
Students shall develop a thorough understanding of the foundations of radiotherapy from a physics and mathematics perspective, focusing on algorithmic components. After completing the course students should be able to implement the main components of a radiotherapy treatment planning system.

Content
Radiotherapy is one of the main treatment options against cancer. Today, more than 50% of cancer patients receive radiation as part of their treatment. Modern radiotherapy is a highly technology driven field.

Research and development in medical physics has improved the precision of radiotherapy substantially. Using intensity-modulated radiotherapy (IMRT), radiation can be delivered precisely to tumors while minimizing radiation exposure of healthy organs surrounding the tumor. Thereby, medical physics has provided radiation oncologists with new curative treatment approaches where previously only palliative treatments were possible. This lecture will provide a detailed introduction to radiotherapy treatment planning and will consists of three blocks:

1. The first part of the course considers the physical interactions of radiation in tissue. The physical interactions give rise to dose calculation algorithms, which are used to calculate the absorbed radiation dose based on a CT scan of the patient.

2. The second part considers the mathematical aspects of treatment planning. Mathematical optimization techniques are introduced, which are used in intensity-modulated radiotherapy to determine the external radiation fields that optimally irradiate the tumor while minimizing radiation dose to healthy organs.

3. The third part deals with additional aspects of central importance for radiotherapy planning. This includes biomedical imaging techniques for treatment planning and target delineation as well as image registration algorithms.

The lectures are followed by computational exercises where students implement the main components of a radiotherapy treatment planning systems in two dimensions in Matlab.

Lecture notes
Lecture slides and handouts.

Prerequisites / notice
Basic programming skills in Matlab (or willingness to learn) are needed for the exercises. Basic knowledge of calculus is needed, approximately corresponding to the 3rd year of a bachelor degree in physics, mathematics, computer science, engineering or comparable discipline.

Other Elective Courses
These courses may be suitable for the Medical Physics track. Please consult your track advisor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>E. Konukoglu, E. Erdil, F. Yu</td>
</tr>
</tbody>
</table>

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

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<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0965-00L</td>
<td>Micro and Nano-Tomography of Biological Tissues</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Stampani, F. Marone Welford</td>
</tr>
</tbody>
</table>

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Biology Courses

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 410 of 2667
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-

**Molecular Bioengineering**

**Track Core Courses**

During the Master programme, a minimum of 12 CP must be obtained from track core courses.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3d animation database/software to use 'anatomical language' to retrieve anatomical structures to understand basic medical terminology</td>
<td></td>
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<tr>
<td>Objective</td>
<td>To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.</td>
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<tr>
<td>Content</td>
<td>- The Human Body: nomenclature, orientations, tissues - Musculoskeletal system, Muscle contraction - Blood vessels, Heart, Circulation - Blood, Immune system - Respiratory system - Acid-Base-Homeostasis</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture notes and handouts</td>
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| Literature   |手

**Physiology and Anatomy for Biomedical Engineers II**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>W</td>
<td>4 credits</td>
<td>4V</td>
<td>V. Vogel, further lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.</td>
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<tr>
<td>Content</td>
<td>Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.</td>
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<tr>
<td>Lecture notes</td>
<td>All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.</td>
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</tbody>
</table>
Objective

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

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Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s anisotropies of biopies.

465-0953-00L  
**Biostatistics**  
4 credits  
2V+1U  
B. Sick

**Abstract**

The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests, measurement of agreement, causality versus association.

- know the commonly used methods in biostatistics  
- perform simple data analysis with R

**Objective**

- Materials and fabrication methods  
- Electromagnetism  
- Electrostatics  
- Scaling laws at micro/nano scales  
- Electrostatics  
- Electromagnetism  
- Low Reynolds number flows  
- Observation tools  
- Materials and fabrication methods  
- Applications of biomedical microrobots

**Lecture notes**

Handout during the course.

### Recommended Elective Courses

These courses are particularly recommended for the Molecular Bioengineering track. Please consult your track advisor if you wish to select other subjects.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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</tbody>
</table>
| **Content** | Main topics of the course include: - Scaling laws at micro/nano scales  
- Electrostatics  
- Electromagnetism  
- Low Reynolds number flows  
- Observation tools  
- Materials and fabrication methods  
- Applications of biomedical microrobots |
| **Lecture notes** | The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically. |
| **Prerequisites / notice** | The lecture will be taught in English. |
| 151-0905-00L | Medical Technology Innovation - From Concept to Clinics               | W    | 4    | 3G    | I. Herrmann      |
Project-oriented learning on how to develop technological solutions to address unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

Lecture notes will be available on the moodle.

Lecture notes will be available on the moodle.

On site presence during (most) of the lectures highly encouraged!

Graded innovation project will require on-site presence.

Literature will be available on the moodle.

Abstract

In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

Important: "qubits" from the point of view of NMR (and NOT from that of quantum computing!).

Content

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM, while corresponding videos of the previous years are available in Moodle !!!

Literature


Supplementary material will be uploaded in Moodle.

---

Prerequisites / Notice

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

---

+ (as rigorous and profound presentation of the mathematical framework) G. Dell'Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer

+ (as account of those formidable years) G. Gamow, "Thirty Years that Shook Physics", 1985, Dover Publications Inc.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity assessed
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

227-0385-10L Biomedical Imaging W 6 credits 5G S. Kozerke, K. P. Prüssmann

Abstract
Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective
Upon completion of the course students are able to:

• Explain the physical and mathematical foundations of diagnostic medical imaging systems
• Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
• Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
• Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Content
• Introduction (intro, overview, history)
• Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
• X-rays (production, tissue interaction, contrast, modular transfer function)
• X-rays (resolution, detection, digital subtraction angiography, Radon transform)
• X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
• Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
• Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
• Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
• Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
• Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
• Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
• Ultrasound (spatial and temporal resolution, phased arrays)
• Ultrasound (Doppler shift, implementations, applications)
• Summary, example exam questions

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011
Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

Prerequisites / notice
Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

227-0386-00L Biomedical Engineering W 4 credits 3G J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.
In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.
Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optical components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.

Lecture notes

Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice

No specific requirements, BUT
ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while
HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract

The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective

During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content

Lecture topics:
1. Introduction
2. Sources of bioelectric signals
3. Membrane and Transport
4. Action potential and Hodgkin-Huxley
5. Measuring bioelectronic signals
6. Detection and Noise
7. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
8. Measuring potentials in solution and core conductance model
9. Measuring mechanical signals with bioelectronics
10. In vivo stimulation and recording
11. Functional electric stimulation
12. Optical recording and control of neurons (optogenetics)
13. Measuring neurons optically, fundamentals of optical microscopy
14. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy
15. Measuring biochemical signals

Lecture notes

A detailed script is provided to each lecture including the exercises and their solutions.

Literature

Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice

The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since lecture handouts and relevant material will be provided.

Cross-disciplinary collaboration between engineers and medical doctors is indispensable for innovation in health care. This course brings together engineering students from ETH Zurich and medical students from the University of Zurich to experience the rewards and challenges of such interdisciplinary work in a project based learning environment.

For the engineering students, the specific aims of the course are to:
- Identify and precisely define a clinical need;
- Acquire a working understanding of the investigated system;
- Identify the engineering challenges in the project and communicate them to the medical students;
- Develop and implement, together with the medical students, solution strategies for the identified challenges;
- Present the solution concept to a cross-disciplinary audience; Preliminary need and solution validation;

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Surfaces and Interfaces I: Fundamentals, Analytics and Applications

Extended course starting HS23. Old title: Surfaces, Interfaces and their Applications I. Students who obtained credit points for the old course cannot retake it.

Abstract
This course teaches the basics of surface and interface science and technology, including surface modifications and forces. It covers various analytical techniques to study surface and interface properties, and explores phenomena of applied relevance like friction, lubrication, phoresis, and wetting where surfaces play a crucial role.

Objective
Students are able to
- describe the physical and chemical properties of surfaces and interfaces.
- analyze and compare analytical tools for surfaces.
- choose and combine appropriate surface-analytical approaches for solving problems connected to applications.
- understand and explain the importance of surfaces and interfaces in a broad range of phenomena and applications.

Content
- Introduction to surfaces and interfaces
- Structure of surfaces over different length scales: from macroscopic roughness to atomic structure
- Surface modifications
- Adsorption and adsorption models
- Surface forces
- Basic physical concepts
- Thermodynamics of surfaces and interfaces
- Measurement of intermolecular and surface forces
- Dynamics and history effects
- Surface analytics: X-ray Photocorrelation Spectroscopy (XPS) – principles and modern developments
- Surface analytics: Secondary Ion Mass Spectroscopy (SIMS) and IR Spectroscopy – Principles and examples
- Atomic Force Microscopy (AFM): Principles and modes of operation
- Tribology: Adhesion, Friction and Lubrication
- Contact mechanics
- Micro and macroscale friction
- Boundary lubrication
- Wetting
- Contact angles
- Phoretic phenomena
- Electric double layer and electrophoresis
- Electro-osmosis
- Other types of phoresis
- Case studies

Lecture notes
Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Literature
Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Prerequisites / notice
Chemistry:
General undergraduate chemistry including basic chemical kinetics and thermodynamics

Physics:
General undergraduate physics including basic theory of interatomic and intermolecular forces, atomic and crystalline structure of materials and their mechanical and electronic properties

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed

Biomineralization

Abstract
The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

Objective
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.
Biominalization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biominalization (BM), types of biominerals and their function, crystal nucleation and growth, biological induction of BM, control of crystal morphology, habit, shape and orientation by organisms, strategies of compartmentalization, the interface between biomolecules (peptides, polysaccharides) and the mineral phase, biomineral experimental methods for studying BM phenomena, inter-, intra, extra- and epitelular BM, organic templates and matrices for BM, structure of bone, teeth (vertebrates and invertebrates) and mollusk shells, calcification, silification in diatoms, radiolarians and plants, calcium and iron storage, impact of BM on lithosphere and atmosphere, evolution, taxonomy of organisms.

1. Introduction and overview
2. Biomineralization and their functions
3. Chemical control of biominalization
4. Control of morphology, Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

Lecture notes

Script with more than 600 pages with many illustrations will be distributed free of charge.

Prerequisites / notice

No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

376-1622-00L  Practical Methods in Tissue Engineering  W  5 credits  4P  M. Zenobi-Wong, S. J. Ferguson, S. Grad, S. Schürle-Finke

Abstract
The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

Objective
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Prerequisites / notice
A laptop is needed with the below Systems Requirements:
- Memory: 16 GB
- Processor: 3rd gen i7
- DirectX 11.0 compliant AMD Radeon/NVIDIA® GeForce® card with 2 GB RAM
- Storage: 15 GB

Mac computer can be used by pre-installing Windows through bootcamp (older Macs) or Parallels Desktop (14d trial license, 35 CHF license purchasable in the IT shop of ETH).

402-0341-00L  Medical Physics I  W  6 credits  2V+1U  P. Manser

Abstract
Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.

Objective
Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefit of patients and the society.

Content
The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionization radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Lecture notes
A script will be provided.

Prerequisites / notice
For students of the MAS in Medical Physics (Specialization A), the performance assessment is offered at the earliest in the second year of the studies.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed
assessed

529-0041-00L  Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics  W  6 credits  3G  R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano

Abstract
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods, mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Lecture notes
Lecture notes will be made available online.

Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

Prerequisites / notice
Exercises are an integral part of the lecture.

Prerequisites:
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)" (or equivalent)
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<td>Self-presentation and Social Influence</td>
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<td>Integrity and Work Ethics</td>
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<td>Personal Competencies</td>
<td>Self-direction and Self-management</td>
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529-0240-00L **Chemical Biology - Peptides**  
**W 6 credits 3G**  
H. Wennemers  

**Abstract**  
An advanced course on the synthesis, properties and function of peptides in chemistry and biology.

**Objective**  
Knowledge of the synthesis, properties and function of peptides in chemistry and biology.

**Content**  
Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.

**Lecture notes**  
Citations from the original literature relevant to the individual lectures will be assigned weekly.

**Literature**  

529-0615-01L **Biochemical and Polymer Reaction Engineering**  
**W 6 credits 3G**  
P. Arosio, P. Fleckenstein  

**Abstract**  

**Objective**  
The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

**Content**  
We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes. Kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

**Lecture notes**  
Scripts are available on the web page of the Arosio-group: [http://www.arosiogroup.ethz.ch/education.html](http://www.arosiogroup.ethz.ch/education.html)

**Literature**  
H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

535-0423-00L **Drug Delivery and Drug Targeting**  
**W 2 credits 1.5V**  
J.-C. Leroux  

**Abstract**  
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

**Objective**  
The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

**Content**  
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

**Lecture notes**  
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

**Literature**  

Further references will be provided in the course.
Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking fostered
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Immunology III

Abstract
This course provides a detailed understanding of
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological textbook knowledge has evolved.

Objective
Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice
Immunology I and II recommended but not compulsory

Other Elective Courses
These courses may be suitable for the Molecular Bioengineering track. Please consult your track advisor.

Biology Courses

Abstract
Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3d animation database/software to retrieve anatomical structures to understand basic medical terminology

Objective
To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.
Abstract
The course during 8 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory.

Objective
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Content
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Prerequisites / notice
Enrollment is limited and students from the Master's programme in Biomedical Engineering (BME) have priority.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving
Project Management

Social Competencies
Communication

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics

Projects and Laboratory Courses
Semester Project

How to Write Scientific Texts

Abstract
This four-hour course covers the basics of writing and presenting scientific work. The focus lies on the structure and the main elements of a scientific text. Formatting guidelines, citation rules, good practice of scientific writing and hints to convince the audience are part of the course.

Objective
- You can write scientific texts using the correct structure
- You can convincingly present scientific work
- You can differentiate the scientific style from novels and news
- You can adhere to citation rules and scientific integrity

Content
The block course covers the following topics:
- Structure of Scientific Texts
- Structure of Scientific Presentations
- Formatting of Scientific Elements (figures, equations, tables)
- Citation Rules and Scientific Integrity

Literature
Scientific Integrity, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
You should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Media and Digital Technologies
Communication

Personal Competencies
Critical Thinking
Self-awareness and Self-reflection

Semester Project 2

Abstract
The semester project is designed to train the students in solving specific biomedical engineering problems. This project uses the technical and social skills acquired during the master's program. The semester project is advised by a professor.

Objective
see above

Research Project (6 credits)

Abstract
Must be completed before the start of the master's thesis

Objective
see above
The five-weeks (full-time) short research project can be done at a research or non-research institution in Switzerland or abroad, but not in a pure industry setting. The project can be done alone or in groups of students, and it is finished with a report and/or prototype. The project must be finished before the start of the Master project.

**Objective**

**227-1760-00L** Research Project (24 credits)  
*Must be completed before the start of the master's thesis*

**Abstract**
The aim of the long research project is to perform a larger (exploratory) scientific study or a larger development project in a team. The duration of this project is at least four months (full-time) and it is finished with a report and/or prototype.

**Objective**

**see above**

**227-1760-00L** Internship in Industry 
*Only for Biomedical Engineering MSc (Programme Regulations 2020).*

**Abstract**
The main objective of the 12-week internship (full-time) is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

**Objective**

**see above**

**Master's Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0 credits</td>
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<td>U. Koch</td>
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</table>

**Abstract**
This four-hour course covers the basics of writing and presenting scientific work. The focus lies on the structure and the main elements of a scientific text. Formatting guidelines, citation rules, good practice of scientific writing and hints to convince the audience are part of the course.

**Objective**
- You can write scientific texts using the correct structure
- You can convincingly present scientific work
- You can differentiate the scientific style from novels and news
- You can adhere to citation rules and scientific integrity

**Content**
The block course covers the following topics:
- Structure of Scientific Texts
- Structure of Scientific Presentations
- Formatting of Scientific Elements (figures, equations, tables)
- Citation Rules and Scientific Integrity

**Literature**
Scientific Integrity, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

**Prerequisites / notice**
You should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

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<td>Social Competencies</td>
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<td>Communication</td>
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<td>Critical Thinking</td>
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<td>Critical Thinking</td>
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<td>Self-awareness and Self-reflection</td>
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</table>

**227-1700-00L** Master's Thesis

**Objective**

**see above**

**Science in Perspective**

Only courses offered under "GESS Science in Perspective" count in this category. See "Offered in" tab in course view. For more information, please refer to https://gess.ethz.ch/en/studies/science-in-perspective/SiP-FAQs.html

**see Science in Perspective: Language Courses ETH/UZH**

**see Science in Perspective: Type A: Enhancement of Reflection Capability**

Recommended Science in Perspective (Type B) for D-
### Generally Accessible Seminars and Colloquia

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<th>Number</th>
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<td>Z</td>
<td>0 credits</td>
<td>1S</td>
<td>K. P. Prüssmann, S. Kozerke, M. Weiger Senften</td>
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</tbody>
</table>

**Abstract**
Current developments and problems of magnetic resonance imaging (MRI)

**Objective**
Getting insight into advanced topics in magnetic resonance imaging

<table>
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<th>Biomedical Engineering Master - Key for Type</th>
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<td>O Compulsory</td>
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<td>S seminar</td>
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<td>K colloquium</td>
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**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Research Project and Industry Internship

**Students can choose between Research Project OR Industry Internship. Duration: 12 weeks full-time min. Must be carried out in a different research group/company than the master’s thesis.**

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<tr>
<td>Abstract</td>
<td>In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student. Research Project duration: 12 weeks, completed with a written report.</td>
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<tr>
<td>Objective</td>
<td>Students get acquainted with scientific working methods and deepen their knowledge in a particular research area</td>
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</tbody>
</table>

| 636-0806-00L | Industry Internship        | W    | 16    | 34A   | Supervisors                       |
| Abstract    | Industry internship of at least 12 weeks, completed with a written report. |
| Objective   | Students gain experience in an industrial environment and an overview of different research areas by applying concepts taught in the courses. |

| Prerequisites / notice | The students look for a placement themselves. |

### Master’s Thesis

**Students can only start with their master’s thesis if**

a. The BSc programme has been completed successfully  
b. Assigned additional requirements for the admission to the master's degree programme have been passed  
c. At least 64 ECTS have been acquired for the master’s degree programme, including 22 ECTS in the core course category and the 16 ECTS in the research projects and internships category

**Abstract**

In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is carried out under the supervision of a professor in a research group of the D-BSSE, usually at the D-BSSE. Students are free to choose the area.

**Objective**

In the Master thesis students prove their ability to independent, structured and scientific working.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>636-0900-10L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>44</td>
<td>91D</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Only for Biotechnologie Master, Programme Regulations 2021. In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is carried out under the supervision of a professor in a research group of the D-BSSE, usually at the D-BSSE. Students are free to choose the area.</td>
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### Master’s Thesis (ONLY for Programme Regulations 2017)

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<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</table>
Practical Training

Students need to acquire a total of 16 ECTS in lab courses. All listed lab courses are mandatory.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0201-00L</td>
<td>Lab Course: Methods in Cell Analysis and Laboratory Automation</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>T. Horn</td>
</tr>
</tbody>
</table>

Abstract
The course Methods in Cell Analysis and Laboratory Automation introduces students to high-end cell analysis and sample preparation methods including image analysis. Students will be taught theoretical aspects and skills in Flow Cytometry, Light Microscopy, Image Analysis, and the use of Laboratory Automation.

Objective
- to understand the technical and physical principles of light microscopes and flow cytometers
- to have hands-on experience in the use of these technologies to analyze/image real samples
- to be able to run a basic analysis of the data and images obtained with flow cytometers and microscopes
- to get introduced to liquid handling (pipetting) robotics and learn how to implement a basic workflow

Content
The practical course will have five units at 2 days each (total 10 days):

1. Flow Cytometry:
   a. Introduction to Flow Cytometry
   b. Practical demonstration on flow cytometry analyzers and flow cytometry cell sorters
   c. Flow cytometry sample preparation
   d. Learn how to use flow cytometry equipment to analyze and sort fluorescence-labeled cells

2. Light microscopy:
   a. Learn how to build a microscope and understand the underlying physical principles
   b. Learn how to use a modern automated wide field fluorescence microscope
   c. Use this microscope to automatically acquire images of a cell culture assay to analyze the dose-dependent effect of a drug treatment

3. Image Analysis
   a. Introduction to the fundamentals of image analysis
   b. Learn the basics of the image analysis software Fiji/ImageJ
   c. Use Fiji/ImageJ to analyze the images acquired during the microscopy exercise

4. Laboratory Automation
   a. Introduction to the basics of automated liquid handling/ lab robotics
   b. See examples on using lab automation for plasmid library generation and cell cultivation
   c. Learn how to program and execute a basic pipetting workflow including liquid handling and labware transfers on Tecan and Hamilton robotic systems

5. Presentations
   a. Each student will be assigned to an individual topic of the course and will have to prepare a presentation on it.
   b. Presentations and discussion in form of a Colloquium

Lecture notes
You will find further information on the practical course and the equipment at:
https://www.bsse.ethz.ch/laf
https://www.bsse.ethz.ch/laf/

Literature
- Microscopy: Murphy and Davidson, Fundamentals of Light Microscopy and Electronic Imaging, John Wiley & Sons, 2012
- Flow Cytometry: Shapiro, Practical Flow Cytometry, John Wiley & Sons, 2005

Prerequisites / notice
The following knowledge is required for the course:
- basic laboratory methods
- basic physics of optics (properties of light, refraction, lenses, fluorescence)
- basic biology of cells (cell anatomy and physiology)

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0203-00L</td>
<td>Lab Course: Microsystems and Microfluidics in Biology</td>
<td>O</td>
<td>3</td>
<td>5P</td>
<td>P. S. Dittrich, A. Hertlemann</td>
</tr>
</tbody>
</table>

Abstract
This practical course is an introduction to microsystems technology and microfluidics for the life sciences. It includes basic concepts of microsystem design, fabrication, and assembly into an experimental setup. Biological applications include a variety of measurements of cellular and tissue signals and subsequent analysis.

Objective
The students are introduced to the basic principles of microsystems technology. They get acquainted with practical scientific work and learn the entire workflow of (a) understanding the theoretical concept, (b) planning the experiment, (c) engineering of the needed device, (d) execution of the experiment and data acquisition, (e) data evaluation and analysis, and (f) reporting and discussion of the results.

Content
The practical course will consist of a set of 4 experiments.

Lecture notes
Notes and guidelines will be provided at the beginning of the course.

Literature

Prerequisites / notice
The practical course will consist of a set of 4 experiments. For each experiment, the student will be required to:
- understand the theoretical concept behind the experiment
- plan the experiment
- engineer the devices
- execute the experiments and acquire data
- evaluate and analyze the data
- report and discuss the results

A good quality of the final report will be expected and be an important criterion.
Lab Course: Microbial Biotechnology

The lab course is open for MSc Biotechnology students only.

**Abstract**
Students will learn the foundations of monocytic working practice and create and screen microbial libraries for identification of strains expressing different fluorescent protein (XFP) levels.

**Objective**
Students will learn the foundations of monocytic working practice and create and screen microbial libraries for identification of strains expressing different fluorescent protein (XFP) levels.

**Content**
- Block A: Handling and preparation of microbial libraries
- D1: Introduction to microbiological cultures and monocytic working techniques.
- D2: Plasmid-based expression systems and variation of XFP synthesis levels via site-directed RBS mutagenesis.
- Block B: Library screening
- D3: In vivo screening for XFP expression levels.
- D4: Analysis of XFP levels via SDS-PAGE analysis. RBS-sequencing.
- Block C: Hit recovery and validation
- D5: In silico analysis of RBS variants.
- D6: Cellular XFP content for selected variants at different culture conditions.
- Block D: Data analysis and presentation
- D7: Protein expression analysis, Q&A for reports and presentations.
- D8: Final presentations and wrap-up.

**Lecture notes**
Material will be provided during the course.

**Literature**

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**Advanced Courses**

*Students need to acquire a minimum of 22 ECTS in this category (MSc Biotechnology Study Programme Regulations 2021). The list of advanced courses is a closed list, no other course can be added to this category.*

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**Biomolecular-Orientated**

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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0103-00L</td>
<td>Microtechnology</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>A. Hierlemann</td>
</tr>
</tbody>
</table>

**Abstract**
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based microdevices and -systems and all related microfabrication processes.

**Objective**
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various microdevices and systems.

**Content**
- Fundamentals of semiconductors and band model
- Fundamentals of devices: transistor and diode.
- Silicon processing and fabrication steps
- Silicon crystal structure and manufacturing
- Thermal oxidation
- Doping via diffusion and ion implantation
- Photolithography
- Thin film deposition: dielectrics and metals
- Wet etching & bulk micromachining
- Dry etching & surface micromachining
- Microtechnological processing and fabrication sequence
- Optional: Packaging

**Lecture notes**
Handouts in English

**Literature**

**Prerequisites / notice**
Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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</tbody>
</table>
636-0104-00L  Biophysical Methods  W  4 credits  3G  D. J. Müller

Abstract  Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective  Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content  The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

The biophysical methods to be taught will include:
- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
- X-ray, electron and neutron diffraction
- MRI imaging
- Scanning tunneling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations

Lecture notes  Hand out will be given to students at lecture.

Literature  Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press

Prerequisites / notice  The course is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

636-0108-00L  Biological Engineering and Biotechnology  W  4 credits  3V  M. Fussenegger

Abstract  Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective  Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.


Lecture notes  Handout during the course.

636-0107-00L  Biotechnology of Enzymes  W  4 credits  3G  S. Panke, A. Bunzel

Abstract  This course covers the role of enzymes in biotechnology, from discovery via engineering to applications in a variety of fields from food to the pharmaceutical industry.

Objective  Students will learn to identify opportunities for utilizing enzymes in biotechnology and develop basic and advanced enzyme engineering skills, informed by the latest research and techniques.

Content  This course offers an in-depth exploration of the use and engineering of enzymes in biotechnology, spanning fundamental enzymology, enzyme engineering, and applied biocatalysis. Topics will include (1) thermodynamic, kinetic, and mechanistic principles of enzyme catalysis, (2) the generation and engineering of enzymes through technologies such as protein design and directed evolution, (3) industrially applied biocatalysis, and (4) future challenges for biocatalysis.

Lecture notes  Notes will be provided in the form of handouts.

Literature  The course will use selected parts of textbooks, original scientific publications, and reviews, which will be shared during the lecture.

Competencies  Subject-specific Competencies
- Concepts and Theories  assessed
- Techniques and Technologies  assessed
- Analytical Competencies  assessed
- Communication  assessed
- Cooperation and Teamwork  assessed
- Self-direction and Self-management  assessed

636-0550-00L  Biomolecular Nanotechnology  W  4 credits  2V+1U  M. Nash

Abstract  Biomolecular Nanotechnology is a broad field that focuses on the study and science of biological materials including DNA, RNA and proteins at length scales below 10 nm. This is a broad overview of the topic with a focus on current research themes.

Objective  The objective is to familiarise the students with a broad range of topics related to biotechnology, nanotechnology, and biophysics with a focus on current research and reading of scientific literature.

Content  Introduction to biomacromolecules: Measurement techniques for characterisation of biomacromolecules; Fundamentals of molecular recognition; Recombinant DNA: Protein engineering; Directed evolution; Protein folding; Polymers; Elastin-like polypeptides; Intelligent materials; Spatially localized hydrogels; Mechanical properties of proteins and macromolecules; Single-molecule force spectroscopy.
Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.

**Content**

- Basic mathematical concepts and tools to explore biochemical reaction dynamics as well as basic concepts from dynamical systems theory.
- Exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Problem-solving

**Personal Competencies**

- Creative Thinking
- Critical Thinking
Microtechnology

Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based microdevices and systems and all related microfabrication processes.

Analytical Competencies

- Critical Thinking
- Integrity and Work Ethics

Concepts and Theories

Introduction to microtechnology, semiconductors, and microelectromechanical systems (MEMS)

- Fundamentals of microtechnology, cleanroom, semiconductor and silicon process technologies
- Students will get to know the different fabrication methods for various microdevices and systems

Content

- Fundamentals of semiconductors and band model
- Fundamentals of devices: transistor and diode
- Silicon processing and fabrication steps
- Silicon crystal structure and manufacturing
- Thermal oxidation
- Doping via diffusion and ion implantation
- Photon lithography
- Thin film deposition: dielectrics and metals
- Wet etching & bulk micromachining
- Dry etching & surface micromachining
- Microtechnological processing and fabrication sequence
- Optional: Packaging

Prerequisites / notice

Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

Competencies

- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

- Concepts and Theories
- Analytical Competencies
- Communication
- Critical Thinking

Lecture notes

Handouts in English


Biophysical Methods

Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Abstract

Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Objective

The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

Content

- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy; transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
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- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations

Lecture notes

Hand out will be given to students at lecture.
**Literature**
Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press
Cell Biology, Pollard & Earnshaw; ISBN-0:7216-3997-6, Saunders, Pennsylvania

**Prerequisites / notice**
The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester credits</th>
<th>Credits</th>
<th>Lecture</th>
<th>Seminar</th>
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<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W 4 credits 3V</td>
<td>M. Fussenegger</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
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<td>Content</td>
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</table>

| Lecture notes | Handout during the course. |

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester credits</th>
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<th>Lecture</th>
<th>Seminar</th>
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<tbody>
<tr>
<td>636-0117-00L</td>
<td>Mathematical Modelling for Bioengineering and Systems Biology</td>
<td>W 4 credits 3G</td>
<td>D. Iber</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>Basic concepts and mathematical tools to explore biochemical reaction kinetics and biological network dynamics.</td>
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<td>The course enables students to formulate, analyse, and simulate mathematical models of biochemical networks. To this end, the course covers basic mathematical concepts and tools to explore biochemical reaction dynamics as well as basic concepts from dynamical systems theory. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Biochemical Reaction Modelling</td>
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<td>Competencies</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Problem-solving</td>
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<td>Personal Competencies</td>
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<td></td>
<td>Creative Thinking</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
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<thead>
<tr>
<th>Course Code</th>
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<th>Semester credits</th>
<th>Credits</th>
<th>Lecture</th>
<th>Seminar</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0118-00L</td>
<td>Introduction to Dynamical Systems with Applications to Biology</td>
<td>W 4 credits 3G</td>
<td>M. H. Khammash</td>
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<td></td>
<td>Abstract</td>
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<td>Many physical systems are dynamic and are characterized by internal variables that change with time. Describing the quantitative and qualitative features of this change is the topic of dynamical systems theory. Dynamical systems arise naturally in virtually all scientific disciplines including physics, biology, chemistry and engineering. This course is a broad introduction to the topic dynamical systems.</td>
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<td>The goal of this course is to introduce the student to dynamical systems and to develop a solid understanding of their fundamental properties. The theory will be developed systematically, focusing on analytical methods for low dimensional systems, geometric intuition, and application examples from biology. Computer simulations using matlab will be used to demonstrate various concepts</td>
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<td>A dynamical view of the world; the importance of nonlinearity; solutions of differential equations; solving equations on the computer; the phase plane; fixed points and stability; linear stability analysis; classifications of linear systems; Liapunov functions and nonlinear stability; cycles and oscillations; bifurcations and bifurcation diagrams. Many biological examples will be used through the course to demonstrate the concepts</td>
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<td>Lecture notes</td>
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<td>Will be provided as needed.</td>
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<tr>
<td></td>
<td>Literature</td>
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**Prerequisites / notice**
Prerequisites: Calculus; a first course in differential equations; basic linear algebra (eigenvectors and eigenvalues). Matlab programming.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester credits</th>
<th>Credits</th>
<th>Lecture</th>
<th>Seminar</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0109-00L</td>
<td>Stem Cells: Biology and Therapeutic Manipulation</td>
<td>W 4 credits 3G</td>
<td>T. Schroeder</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.</td>
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<td>Objective</td>
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<td></td>
<td>Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.</td>
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We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

While no specific textbook will be followed, much of the material and homework problems will be taken from the following books:

- Concepts and Theories
- Techniques and Technologies
- An Introduction to Probability Theory and Stochastic Processes with Applications to Biology
- Analytical Competencies
- Media and Digital Technologies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Critical Thinking
- Integrity and Work Ethics

The aim of this course is to introduce certain topics in Probability Theory and Stochastic Processes that have been specifically selected, assessed, fostered, and encouraged. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.

The course will involve a healthy balance between mathematical rigor (theorem proving) and biological applications. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.

The electives list in the ETH course catalogue is an open list, and the courses listed in the ETH course catalogue provide just examples for possible elective courses, e.g., a selection of eligible courses. Students are expected to look for relevant courses in the ETH and University of Basel course catalogue and ask their mentor for approval. Courses from the advanced course category may also be taken as electives.

We particularly recommend browsing the University of Basel course catalogue for elective courses of relevant master's degree programs (using the filter "program structure" on the course catalogue website), such as for example: Biomedical Engineering, Chemistry, Drug Sciences, Epidemiology, Infection Biology, Molecular Biology, Nanosciences.

The first half of the course will cover the basics of Probability Theory while the second half will delve into the theory of Stochastic Processes. Below is the list of topics that will be covered in the course.

1. The mathematical representation of random phenomena: The probability space, properties of the probability measure, independence of events, Conditional probability and Bayes formula, applications to parameter inference.
3. Convergence of Random Variables: Modes of convergence, Laws of large numbers, the central limit theorem, the law of the iterated logarithm, Applications to the analysis of cell population data.

While no specific textbook will be followed, much of the material and homework problems will be taken from the following books:

- Computational Biology

The course will involve a healthy balance between mathematical rigor (theorem proving) and biological applications. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.
Objective

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

* epidemiology
* pathogen evolution
* macroevolution of species

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS.

Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

* Yang, Z. 2006. Computational Molecular Evolution.
* Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving

Personal Competencies

- Creative Thinking
- Critical Thinking

Lecture notes

Lecture slides will be available on moodle.

Prerequisites

- Basic knowledge in linear algebra, analysis, and statistics
- Programming in R

Literature

- * Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving

Personal Competencies

- Creative Thinking
- Critical Thinking

Content

1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

Lecture notes

All lecture material will be made available online via Moodle.

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The course is structured in four main pillars:

1. **Lecture slides will be available**
2. **The modern tools of chemical biology will be discussed and contextualized with a discussion of practical applications with those tools.**

### Prerequisites

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

### 636-0119-00L Introduction to Statistics and R

**W** 6 credits 3G+2A J. Kuipers

**Abstract**

This course offers a practical introduction to the fundamentals of data analysis and R

**Objective**

To acquire the statistical understanding to design an appropriate analysis and the practical skills to implement the analysis in R and present the results.

**Content**

Data analysis is fundamental for arriving at scientific conclusions and testing different hypotheses. This course offers a hands-on introduction to statistical analyses including: exploratory data analysis, testing differences in populations, p-values, power calculations, multiple testing, confounding, linear regression, maximum likelihood, model selection, and logistic regression; along with the fundamentals of R programming including markdown and data handling with the tidyverse.

**Lecture notes**

Lecture slides will be available

**Prerequisites / notice**

Access to Rstudio with some markdown and tidyverse packages installed.

### 636-0120-00L Introduction to Programming

**Z** 0 credits 1G A. Gupta, T. Vaughan

**Abstract**

This is a voluntary programming course “before” the start of the semester, open for students of the MSc Biotechnology master's programme only. Lecture dates: 2-13 September 2024. Students are asked to sign up for the course in myStudies as well as via the online form (link sent out via e-mail).

**Objective**

The goal of this course is to give students, who have no prior programming background, a solid introduction to algorithm development and its successive implementation in a programming language. For students with previously acquired programming skills, the course will serve as a reinforcement of key aspects of structured programming in addition to providing a well-rounded introduction to MATLAB, R and Python.

**Content**

The course is structured in four main pillars:

- **Logical thinking:** Translating a problem into a conceptual sequence of computational steps. For example:
  - **[Problem]** What is the GC content of a given DNA string?
  - **[Logical steps]**
    - i) Iterate through all nucleotides in the DNA string, one by one
    - ii) Count the Cs or Gs
    - iii) Divide the count of Cs or Gs by the length of the DNA string
    - iv) Report the result.

- **The basics of programming:** Variables, functions and arrays. Control flow and recursion. Top-down algorithm design. Computational complexity of an algorithm.

- **Writing code:** Full introduction to the MATLAB programming language and covers Bash scripting and other programming languages such as R and Python.

- **Primer of Unix commands:** Command-line examples on how to access servers and computing resources at the D-BSSE. Submission of jobs to the EULER cluster.

**Lecture notes**

Available on course website (Moodle)

**Literature**

Publicly available material (links will be posted on the course website)

### 636-0552-00L Metals in Biology (University of Basel)

**W** 3 credits 3G external organisers

**Abstract**

Mind the enrolment deadlines at Uni Basel: https://www.unibas.ch/en/Studies/Mobility/Mobility-Switzerland/Students-Registering-From-Other-Swiss-Universities.html

**Objective**

- Identify key features of metalloenzymes and enzyme mimics
- Deduce and draw reasonable reaction mechanisms catalyzed by metalloenzymes
- Understand the role of metalloenzymes in solving energy-related grand challenges
- Design functional enzyme mimics
- Critically analyze the structure and function of metalloproteins

### 636-0553-00L Chemical Biology (University of Basel)

**W** 3 credits 3G external organisers

**Abstract**

Mind the enrolment deadlines at Uni Basel: https://www.unibas.ch/en/Studies/Mobility/Mobility-Switzerland/Students-Registering-From-Other-Swiss-Universities.html

**Objective**

- The course must be registered for directly at Uni Basel.
- The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

### 636-0551-00L Supramolecular Chemistry (University of Basel)

**W** 3 credits 2V K. Tiefenbacher

**Abstract**

The modern tools of chemical biology will be discussed and contextualized with a discussion of practical applications with those tools.
The course must be registered for directly at Uni Basel. 

Uni Basel course number: 46486-01

Mind the enrolment deadlines at Uni Basel:
https://www.unibas.ch/en/Studies/Mobility/Mobility-Switzerland/Students-Registering-From-Other-Swiss-Universities.html

Abstract
This course provides an introduction to supramolecular chemistry. Prior knowledge in supramolecular chemistry is not a prerequisite for this course.

Objective
After this course, the student is expected to understand and be able to apply the basics of supramolecular chemistry: host-guest interactions, host design, self-assembly and simple enzyme mimetics.

Content
This course provides an introduction to supramolecular chemistry. Prior knowledge in supramolecular chemistry is not a prerequisite for this course. We will first cover the basic concepts of supramolecular chemistry: non-covalent interactions, host-guest chemistry, binding constant determination and binding strength. Subsequently, we will take a closer look at how to bind different species: cations, anions and neutral organic molecules. Towards the end of the semester, we will cover self-assembly processes and applications of supramolecular structures as simple enzyme mimetics.

Lecture notes
The lecture slides are provided online via ADAM. No additional literature is required. If additional information is desired, the book "Supramolecular Chemistry" by Jonathan W. Steed and Jerry L. Atwood (John Wiley & Sons) is recommended.

636-0554-00L Modelling and Simulation in Drug Development

W 2 credits 3V H.-M. Kaltenbach

Abstract
This course introduces how Modelling and Simulation (=mathematical modelling) is applied today for the development of novel drugs in the pharmaceutical industry. Background lectures are combined with hands-on exercises on real-world examples.

Objective
The goal of this course is to provide students with a general understanding of drug development and pharmacology and how Modelling and Simulation is used to develop new drugs. Together with the application, the course will provide the background in the statistical methodologies used to model multivariate and time-dependent data with several levels of statistical variability.

Content
Understanding the pharmacology, pharmacokinetics and pharmacodynamics (PK/PD) of novel drugs is key for a successful drug development process. Modelling and Simulation of these data at the core to gain this understanding. Focusing on the application using real world examples, this course will introduce the statistical methodologies that have been developed to describe complex biological and pharmacological data with several levels of statistical variability.

The course will cover the basics of drug development and pharmacology with a focus on the principles of drug absorption, distribution, metabolism and excretion (ADME) and drug pharmacokinetics and pharmacodynamics (PK/PD). The different drug formats (small molecules, biologics, cell-based therapies, gene therapies and oligonucleotide formats) and their pharmacological properties will be introduced. The translation from animal to human to inform first-in-human dose selections will be discussed.

The methodology part will cover compartmental PK/PD modelling, the practical aspects of numerical solutions of ordinary differential equations (ODEs) and the theory on non-linear mixed effects (NLME) modelling, which has become the de-facto standard methodology in the pharmaceutical industry. The practical problems of Modelling and Simulations will be discussed including parameter identifiability, model development and model evaluation and the application (or not) of the Occam’s Razor.

The course will focus on hands-on exercises using contemporary real-world examples from the pharmaceutical industry and provide necessary theoretical and methodological background in accompanying lectures.

Prerequisites / notice
Basics of dynamic systems (e.g., BSSE courses by Iber or Kamnash, or CSB course by Stelling)
Basics of statistics and R (e.g., BSSE courses by Kuipers or Kaltenbach)

Science in Perspective
see Science in Perspective: Language Courses ETH/UZH
see Science in Perspective: Type A: Enhancement of Reflection Capability

Biotechnology Master - Key for Type

O Compulsory E- Recommended, not eligible for credits
W+ Eligible for credits and recommended Z Courses outside the curriculum
W Eligible for credits Dr Suitable for doctorate

Key for Hours

V lecture P practical/laboratory course
G lecture with exercise A independent project
U exercise D diploma thesis
S seminar R revision course / private study
K colloquium

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
As a final module, new business models are discussed and explored. Examples will be used to explore patterns and interfaces and to discuss the opportunities and risks.

How do the experiences of other industries help us? What can be derived from them? Why is BIM only a small part and why is the future of BIM not BIM?

Module 3 focuses on cultural change, innovation, disruption or evolution? In this last model, we learn to question and discover what the 17 Sustainable Goals mean for our industry.

The module offers the opportunity to prepare for the voluntary buildingSMART Professional Certification.

We learn to consciousness look at the topic of added value and digital transformation from different perspectives. Collision checking and quantity take-offs (QTO) are very useful. But they are only basics when it comes to real value creation.

We will analyse the topic on the basis of two concrete examples, familiarise ourselves with them and observe their further development as a result.

### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>072-0101-00L</td>
<td>Module 1: Foundations of Digitalisation</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<tr>
<td>Abstract</td>
<td>Key terms: Digital transformation is more than digitisation of existing processes and information</td>
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<tr>
<td>Objective</td>
<td>Independently of the building industry, Module 1 initially provides information about the characteristics of digitalisation through its principles and rules, enabling the participants to independently recognise the short-term and long-term changes that are resulting from it.</td>
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<tr>
<td>Content</td>
<td>The first module addresses the topic of digitalisation and digital transformation in a holistic sense. It is much more than converting documents into PDFs or using software. It is about transforming processes, resources and information into a consistent and efficient digital system to make life easier for employees and customers. This journey always involves change. From the perspective of other industries, we first build up a basic understanding and discuss the opportunities and risks.</td>
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<tr>
<td>Literature</td>
<td>Literature recommendations at <a href="http://www.bauprozess.arch.ethz.ch">www.bauprozess.arch.ethz.ch</a> and <a href="http://www.kompetenz.arch.ethz.ch">www.kompetenz.arch.ethz.ch</a></td>
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<tr>
<td>Literature</td>
<td>Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.</td>
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<td>Lecture notes</td>
<td>Literature recommendations at <a href="http://www.bauprozess.arch.ethz.ch">www.bauprozess.arch.ethz.ch</a> and <a href="http://www.kompetenz.arch.ethz.ch">www.kompetenz.arch.ethz.ch</a></td>
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<tbody>
<tr>
<td>072-0102-00L</td>
<td>Module 2: Collaboration</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
<tr>
<td>Abstract</td>
<td>Key terms: “Behaviour for Collaboration” - Structural questions on collaboration and the patterns of behaviour.</td>
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<tr>
<td>Objective</td>
<td>In Module 2, we break from the theoretical idea of a purely technology-based, better collaboration and look at the situation realistically in order to be able to understand and develop new solutions and requirements.</td>
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<tr>
<td>Content</td>
<td>The usual approach towards digital transformation is to train people to use new technologies. In contrary, we ask for the specific challenges and problems people have with change. We learn to understand viewpoints of different partners within building projects and new solutions to specific problems.</td>
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<td>Literature</td>
<td>Literature recommendations at <a href="http://www.bauprozess.arch.ethz.ch">www.bauprozess.arch.ethz.ch</a> and <a href="http://www.kompetenz.arch.ethz.ch">www.kompetenz.arch.ethz.ch</a></td>
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<tr>
<td>072-0103-00L</td>
<td>Module 3: Foundation of Automation</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
<tr>
<td>Abstract</td>
<td>Key terms: Managed data, semantics and file formats</td>
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<tr>
<td>Objective</td>
<td>Module 3 leaves behind the negative images from the early days of automation. A gloomy and misanthropic image of automation - both a bliss and a curse. We get to know the positive sides and learn to apply them. How do we become a sustainable “Formula 1”?</td>
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<td>Content</td>
<td>What does it take to be able to work together in a digitally networked environment? How many “techie genes” are needed to work efficiently and effectively with structured data? The third module gives an insight into the principles of data architectures, data formats, attributes and platform technology. Machine readability as an important requirement but also as a clear challenge e.g. to security requirements.</td>
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<tr>
<td>Literature</td>
<td>Literature recommendations at <a href="http://www.bauprozess.arch.ethz.ch">www.bauprozess.arch.ethz.ch</a> and <a href="http://www.kompetenz.arch.ethz.ch">www.kompetenz.arch.ethz.ch</a></td>
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<tbody>
<tr>
<td>072-0104-00L</td>
<td>Module 4: Foundation of Value Creation</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
<tr>
<td>Abstract</td>
<td>Key terms: Added value of digital transformation, distributed data management, digital twin, logistics and robotics.</td>
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<td>Objective</td>
<td>Using specific examples, Module 4 illustrates the foundations and versatility of building information modeling (BIM), enabling participants to deal with the concepts, applications and mechanisms involved.</td>
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<tr>
<td>Content</td>
<td>“Highway to hell or highway to haven” - the question of a clear and simple roadmap is always at the heart of a digital transformation. “Value creation” is a central goal. Digitalisation is often seen as a strategy from the productivity gap. The fourth module shows how strategic goals can be developed in a roadmap and implemented in practice and how the individual shareholders and stakeholders participate.</td>
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<tr>
<td>Literature</td>
<td>Literature recommendations at <a href="http://www.bauprozess.arch.ethz.ch">www.bauprozess.arch.ethz.ch</a> and <a href="http://www.kompetenz.arch.ethz.ch">www.kompetenz.arch.ethz.ch</a></td>
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<td>Lecture notes</td>
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<tbody>
<tr>
<td>072-0105-00L</td>
<td>Module 5: New Business Models</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
<tr>
<td>Abstract</td>
<td>Key terms: Business models, cultural change, disruption, evolution, lean methods</td>
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<td>Objective</td>
<td>Module 5 focuses on cultural change, innovation, disruption or evolution? In this last model, we learn to question and discover what the 17 Sustainable Goals mean for our industry.</td>
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<tr>
<td>Content</td>
<td>As a final module, new business models are discussed and explored. Examples will be used to explore patterns and interfaces and to analyse what is needed today and in the future for a successful and sustainable development of the sector. How can innovative ideas move us forward? What can we learn from design thinking? Why is it important for people to have useful and understandable measurable values? How do the 17 Sustainable Goals influence our industry?</td>
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### Term Paper

The Term Paper is offered in spring semesters only.

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Recommended, not eligible for credits
Courses outside the curriculum
Suitable for doctorate

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 435 of 2667
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Core Courses

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<td>- Duties and tasks, liability</td>
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### Term Paper

**Offered in the Spring Semester.**

## CAS ARC in Project Leadership - Key for Type

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<td>R</td>
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**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
In Module 1, by interpreting the snapshot of one's own enterprise and opportunities and dangers.

**Key words:** construction and real estate market, micro and macro environment

**Abstract**

In Module 1, by interpreting the snapshot of one's own enterprise and opportunities and dangers to appreciate.

**Content**

Introductory module «Enterprise» considers the role of organizations in the economic network of markets and their identity. It presents the peculiarities of planning offices as a service provider, shows different types of companies and discusses the business cycle from founding to succession planning. In addition, the branch-specific development of leadership and organizational models as well as the problem of access to international markets are examined. Accompanying the basics of a general business model for service companies are taught and key criteria defined.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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**Module 2: State of the Art**

**Key words:** construction and renovation, economy

**Abstract**

Change in value, demolition / replacement, potential for compression

**Objective**

Knowledge about type, extent and change of the building Switzerland and the main questions.

**Content**

With more than CHF 3'585 billion (excluding land), Switzerland is the largest national capital. It grows by around 4.7 per cent each year, but its value is under-invested. Is there a risk of slippage? Should more be invested in maintenance / repair or more canceled and replaced?

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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**Module 3: Economic Interest**

**Key words:** intention development, realization operation

**Abstract**

The participants understand a property in the context of a life cycle

**Objective**

The importance of a life-cycle-oriented approach has arrived in the Swiss construction and real estate sector. Cumulative management costs can exceed the cost of construction after just a few years. In this module, a systematic consideration of the phases and processes in the life cycle of a property takes place. Study I explores various aspects of life-cycle planning and construction.

**Content**

The life cycle of the building and the impact of interventions on the life cycle of the building stock.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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**Module 4: Course of Action**

**Key words:** maintenance, change, replacement

**Abstract**

Preservation of value, increase in value, destruction of value and replacement construction

**Objective**

The various depths of intervention in dealing with a existing property and their effects are known.

**Content**

The structure and nomenclature of the interventions in the stock are presented and models for the registration and calculation of the implications for selective decommissioning, disposal, landfilling, recycling and reuse, as well as the importance of the gray matter energy of building materials.

**Lecture notes**

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**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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**Module 5: Life Cycle and Resources**

**Key words:** building fabric, material cycle

**Abstract**

Production and disposal / reusability of building fabric, energy flows, pollutants

**Objective**

Building and breaking off is understood as an energy and material flow.

**Content**

The total weight of all properties in Switzerland is estimated at around 1 billion tonnes. Every year around 10 million m3 of buildings are demolished and more than 80 million t of raw materials are used in new buildings. This module examines the cycle principle and its implications for selective decommissioning, disposal, landfilling, recycling and reuse, as well as the importance of the gray matter energy of materials.

**Lecture notes**

Continuation, reuse, demolition / new construction - stakeholders, goals and conflicting goals

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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**Term Paper**

The term paper is offered in spring semester only.

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**CAS ARC in Real Estate Strategies urban-peri-urban - Key for Type**

**O** Compulsory

**W+** Eligible for credits and recommended

**W** Eligible for credits

**E-** Recommended, not eligible for credits

**Z** Courses outside the curriculum

**Dr** Suitable for doctorate

**Key for Hours**

**V** lecture

**G** lecture with exercise

**U** exercise

**S** seminar

**K** colloquium

**P** practical/laboratory course

**A** independent project

**D** diploma thesis

**R** revision course / private study

**ECTS** European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
A. Paulus

The aim is to use a snapshot in time to interpret one’s own company and become able to assess opportunities and risks. The “company” module considers the role of organisations within the economic network of the markets and the nature of their identity. It presents the special aspects of planning offices as service providers, illustrates various types of company, and discusses companies’ lifecycle as they move from their founding to the period of planning for the succession. Both sector-specific development of management and organizational models and also the problems of obtaining access to international markets are also investigated. Alongside this, the foundations of a generally valid business model for service companies are described and key criteria are defined.

Lecture notes:
- Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature:
- Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Module 2: Acquisition

Key terms: Competence, communication and network

The aim is to become able to analyse and implement the processes and instruments used for acquisition in one’s own company. Acquisition represents a separate project in entrepreneurial activity, since all the activities involved in obtaining a commission fall under this term. The “acquisition” module focuses on imparting basic knowledge of networking and professional dialogue. Both of these tools require an assessment of one’s own situation with regard to competence, resources and customer relations. The conversation is a direct interaction; everyone involved is both an addressee and also basically an equal interlocutor. Networking can be learned: situational “small talk,” social competence and a healthy ability to communicate can be learned.

Lecture notes:
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Literature:
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Module 3: Marketing

Key terms: Planning, positioning and identity

The aim is to become familiar with the tools used in marketing and able to use them in specific situations. Marketing means orienting company activities towards market demands. Communication between suppliers, clients and the competition plays the decisive role here. The “marketing” module illustrates the foundations of marketing planning for architects and engineers. The essential definitions are provided and the core tasks involved in marketing are described. On this basis, the way in which a marketing plan is developed is explained and strategic and operational marketing planning is described in detail. The topics of branding and the opportunities represented by press and public relations work for architects and planners round out the “marketing” module.

Lecture notes:
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Module 4: Financial Management

Key terms: Cost accounting, budgeting and controlling

The aim is to become able to analyse one’s own company’s financial resources in detail, interpret key parameters for the current situation and test them. Financial management means achieving the target company output with costs that are as low as possible, and in the longer term to create secure asset and capital structures. The tasks involved in financial management in a planning office include establishing a well-structured accounting department, careful cost accounting, sound budgeting and an effective controlling system. On the basis of a practical financial structure for architecture and engineering offices, the “financial management” module presents the information needed to carry these tasks out in a professional and responsible way.

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Module 5: Digitalisation

Key terms: Strategy, potentials and digital planning

The aim is to become familiar with the current practical work involved in IT in planning companies and be able both to analyze the specific challenges it implies and also to infer one’s own prospects for development in this context. In addition, thought needs to be given to the way in which the value creation provided by digitalisation influences one’s own company. IT refers on the one hand to information and data processing in a company, and on the other to the hardware and software components needed for the purpose. This “information technology” module focuses on potential strategies for company management in the IT field. The focus is not on the use of any individual programme, but on taking conscious decisions for or against IT components in one’s own company in order to obtain helpful support in one’s everyday work. The strengths, weaknesses, opportunities and risk of this strategy suggest possible potentials.

The participants will present their own theses on entrepreneurship and open them up for discussion in the plenary session.

Lecture notes:
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**CAS ARC in Unternehmensführung - Key for Type**

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**CAS ARC in Unternehmensführung - Term Paper**

Offered in the Spring Semester.

**Literature Recommendations**
- www.bauprozess.arch.ethz.ch
- www.kompetenz.arch.ethz.ch
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<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
CAS Module A in Advanced Materials and Processes

**Number**: 344-0100-00L  
**Title**: CAS Module A in Advanced Materials and Processes  
**Type**: W  
**ECTS**: 12 credits  
**Hours**: 26A  
**Lecturers**: Professors

**Abstract**: CAS AMaP participants are offered a MaP professor as a mentor together with whom they design their study plan along an individually-specified focus area in 'Advanced Materials and Processes'. Building on the individual expertise, interests and needs of the participants, the customised CAS AMaP module consists of the elements: (i) research project, (ii) courses and lectures, (iii) knowledge transfer.

**Objective**: The CAS AMaP module is fully customisable, building on the expertise of technical specialist professionals and aims at:  
- training skills at the frontiers of the current state of research in Advanced Materials and Processes,  
- deepening technical know-how with state-of-the-art knowledge in the specified focus area, and  
- advancing practical competencies in the impart of expertise and knowledge transfer across disciplines and educational levels.

**Content**: CAS AMaP participants are offered a MaP professor as a mentor together with whom they design their study plan along an individually-specified focus area in 'Advanced Materials and Processes'. Building on the individual expertise, interests and needs of the participants, the customised CAS AMaP module consists of the elements: (i) research project, (ii) courses and lectures, (iii) knowledge transfer.

Depending on individual interests and needs of the technical specialist professionals, the CAS AMaP module consists of the elements:  
I. conducting a research project in the mentor’s group, addressing fundamental, development or applied problems, considering theoretical and/or experimental aspects,  
II. individual schedule of courses and lectures with state-of-the-art knowledge, and  
III. sharing of know-how in, e.g. seminars and interactive formats, thereby enhancing bidirectional knowledge transfer.

CAS Module B in Advanced Materials and Processes

**Number**: 344-0110-00L  
**Title**: CAS Module B in Advanced Materials and Processes  
**Type**: W  
**ECTS**: 9 credits  
**Hours**: 19A  
**Lecturers**: Professors

**Abstract**: CAS AMaP participants are offered a MaP professor as a mentor together with whom they design their study plan along an individually-specified focus area in 'Advanced Materials and Processes'. Building on the individual expertise, interests and needs of the participants, the customised CAS AMaP module consists of the elements: (i) research project, (ii) courses and lectures, (iii) knowledge transfer.

**Objective**: The CAS AMaP module is fully customisable, building on the expertise of technical specialist professionals and aims at:  
- training skills at the frontiers of the current state of research in Advanced Materials and Processes,  
- deepening technical know-how with state-of-the-art knowledge in the specified focus area, and  
- advancing practical competencies in the impart of expertise and knowledge transfer across disciplines and educational levels.

**Content**: CAS AMaP participants are offered a MaP professor as a mentor together with whom they design their study plan along an individually-specified focus area in 'Advanced Materials and Processes'. Building on the individual expertise, interests and needs of the participants, the customised CAS AMaP module consists of the elements: (i) research project, (ii) courses and lectures, (iii) knowledge transfer.

Depending on individual interests and needs of the technical specialist professionals, the CAS AMaP module consists of the elements:  
I. conducting a research project in the mentor’s group, addressing fundamental, development or applied problems, considering theoretical and/or experimental aspects,  
II. individual schedule of courses and lectures with state-of-the-art knowledge, and  
III. sharing of know-how in, e.g. seminars and interactive formats, thereby enhancing bidirectional knowledge transfer.

CAS Module C in Advanced Materials and Processes

**Number**: 344-0120-00L  
**Title**: CAS Module C in Advanced Materials and Processes  
**Type**: W  
**ECTS**: 6 credits  
**Hours**: 13A  
**Lecturers**: Professors

**Abstract**: CAS AMaP participants are offered a MaP professor as a mentor together with whom they design their study plan along an individually-specified focus area in 'Advanced Materials and Processes'. Building on the individual expertise, interests and needs of the participants, the customised CAS AMaP module consists of the elements: (i) research project, (ii) courses and lectures, (iii) knowledge transfer.

**Objective**: The CAS AMaP module is fully customisable, building on the expertise of technical specialist professionals and aims at:  
- training skills at the frontiers of the current state of research in Advanced Materials and Processes,  
- deepening technical know-how with state-of-the-art knowledge in the specified focus area, and  
- advancing practical competencies in the impart of expertise and knowledge transfer across disciplines and educational levels.

**Content**: CAS AMaP participants are offered a MaP professor as a mentor together with whom they design their study plan along an individually-specified focus area in 'Advanced Materials and Processes'. Building on the individual expertise, interests and needs of the participants, the customised CAS AMaP module consists of the elements: (i) research project, (ii) courses and lectures, (iii) knowledge transfer.

Depending on individual interests and needs of the technical specialist professionals, the CAS AMaP module consists of the elements:  
I. conducting a research project in the mentor’s group, addressing fundamental, development or applied problems, considering theoretical and/or experimental aspects,  
II. individual schedule of courses and lectures with state-of-the-art knowledge, and  
III. sharing of know-how in, e.g. seminars and interactive formats, thereby enhancing bidirectional knowledge transfer.

### CAS in Advanced Materials and Processes - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
</tr>
<tr>
<td>V</td>
<td>lecture</td>
<td>P</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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### Key for Hours

<table>
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<th>Type</th>
<th>Description</th>
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<tr>
<td>V</td>
<td>lecture</td>
<td>practical/laboratory course</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>revision course / private study</td>
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### ECTS

European Credit Transfer and Accumulation System  
Special students and auditors need special permission from the lecturers.
CAS in Applied Earth Sciences

► Modules Geo-Resources

The Module Geo-Resources runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS25 + HS25

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>669-0102-00L</td>
<td>Autumn Course: Geothermal Usage of the Subsurface</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>M. O. Saar</td>
</tr>
</tbody>
</table>

Abstract
The block course focuses on shallow groundwater wells and ground heat exchangers, but also expands the spectrum to include geothermal energy and geostorage potential in Switzerland. The contributions address, among other things, the question of how, with increased use of geothermal resources, conflicts of use due to the growing number of uses can be dealt with.

Objective
The aim of the course is for participants to be able to describe the basic processes of geothermal use and to understand the regulatory framework. They will be able to assess the mutual influence of the uses and know possibilities to take these into account in strategic planning.

► Modules Geo-Constructs

The Module Geo-Constructs runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS23 + HS23

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>669-0202-00L</td>
<td>Fall Course: Characterisation of Rock and Rock Mass Behaviour for Underground Excavations</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>J. Aaron</td>
</tr>
</tbody>
</table>

Abstract
The course focuses on the characterization of rock as a basis for describing rock mass behaviour with the help of hazard scenarios that are used in the planning and construction of underground excavations.

Objective
Participants learn the geological, geomechanical and hydrogeological factors necessary for the assessment and are able to estimate the influence of geological conditions on underground excavations.

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed
Social Competencies: Cooperation and Teamwork fostered
Personal Competencies: Critical Thinking fostered

► Modules Geo-Risks

The Module Geo-Risks runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS24 + HS24

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>669-0302-00L</td>
<td>Autumn Course: Landslide Process and Hazards</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>J. Aaron, V. Gischig, A. Manconi</td>
</tr>
</tbody>
</table>

Abstract
The autumn course provides current and new knowledge needed for classification, determination of the relevant processes and estimation of the temporal behaviour of geological mass movements.

Objective
The participants learn which investigations and measurements can be used to improve the hazard analysis in a targeted manner, especially for more complex slope instabilities.

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed
Social Competencies: Cooperation and Teamwork fostered
Personal Competencies: Critical Thinking fostered

CAS in Applied Earth Sciences - Key for Type

O  Compulsory
W+ Eligible for credits and recommended
W  Eligible for credits
E- Recommended, not eligible for credits
Z  Courses outside the curriculum
Dr Suitable for doctorate

Key for Hours

V  lecture
G  lecture with exercise
U  exercise
S  seminar
K  colloquium
P  practical/laboratory course
A  independent project
D  diploma thesis
R  revision course / private study

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### CAS in Applied Statistics

#### Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-0649-01L</td>
<td>Applied Statistical Regression I</td>
<td>O</td>
<td>4 credits</td>
<td>1V+1U</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>Simple and multiple regression models, with emphasis on practical aspects and interpretation of results, analysis of residuals and model selection.</td>
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| 447-0625-01L | Applied Analysis of Variance and Experimental Design I | Z    | 3 credits | 1V+1U |           |
|              | Does not take place this semester.          |      |          |       |           |
| Abstract     | Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs. |      |          |       |           |
| Objective    | Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R. |      |          |       |           |
| Competencies | Subject-specific Competencies               |      |          |       |           |
|              | Concepts and Theories                       |      | assessed |       |           |
|              | Methods and Technologies                    |      | assessed |       |           |
|              | Method-specific Competencies                |      |          |       |           |
|              | Analytical Competencies                     |      | assessed |       |           |
|              | Decision-making                             |      | assessed |       |           |
|              | Personal Competencies                       |      |          |       |           |
|              | Critical Thinking                           |      | assessed |       |           |

### Further Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-0649-02L</td>
<td>Applied Statistical Regression II</td>
<td>Z</td>
<td>2 credits</td>
<td>1V+1U</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>Generalized linear models (GLMs) and basic ideas of more advanced regression models.</td>
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<tr>
<td>Objective</td>
<td>Understanding the concept and flexibility of generalized linear models and correct interpretation of the corresponding model outputs.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
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<tr>
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<td>Concepts and Theories</td>
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<td>Methods and Technologies</td>
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<td>assessed</td>
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<td>Method-specific Competencies</td>
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<td>Critical Thinking</td>
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<td>assessed</td>
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| 447-0625-02L | Applied Analysis of Variance and Experimental Design II | Z    | 3 credits | 1V+1U |           |
|              | Does not take place this semester.          |      |          |       |           |
| Abstract     | Random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power. |      |          |       |           |
| Objective    | Participants will be able to plan and analyze sophisticated experiments in the fields of natural sciences. They will gain practical experience by using the software R. |      |          |       |           |
| Competencies | Subject-specific Competencies               |      |          |       |           |
|              | Concepts and Theories                       |      | assessed |       |           |
|              | Methods and Technologies                    |      | assessed |       |           |
|              | Method-specific Competencies                |      |          |       |           |
|              | Analytical Competencies                     |      | assessed |       |           |
|              | Decision-making                             |      | assessed |       |           |
|              | Personal Competencies                       |      |          |       |           |
|              | Critical Thinking                           |      | assessed |       |           |

| 447-6221-00L | Nonparametric Regression                   | W    | 1 credit | 1G    | M. Mächler |
|              | Does not take place this semester.        |      |          |       |           |
| Abstract     | This course focusses on nonparametric estimation of probability densities and regression functions. These recent methods allow modelling without restrictive assumptions such as 'linear function'. These smoothing methods require a weight function and a smoothing parameter. Focus is on one dimension, higher dimensions and samples of curves are treated briefly. Exercises at the computer. |      |          |       |           |
| Objective    | Knowledge on estimation of probability densities and regression functions via various statistical methods. Understanding of the choice of weight function and of the smoothing parameter, also done automatically. Practical application on data sets at the computer. |      |          |       |           |
| Competencies | Subject-specific Competencies               |      |          |       |           |
|              | Concepts and Theories                       |      | assessed |       |           |
|              | Methods and Technologies                    |      | assessed |       |           |
|              | Method-specific Competencies                |      |          |       |           |
|              | Analytical Competencies                     |      | assessed |       |           |
|              | Decision-making                             |      | assessed |       |           |
|              | Personal Competencies                       |      |          |       |           |
|              | Critical Thinking                           |      | assessed |       |           |

| 447-6257-00L | Repeated Measures                          | W    | 1 credit | 1G    | M. L. Spohn |
|              | Does not take place this semester.        |      |          |       |           |
| Objective    | Participants will gain the ability of recognizing repeated measures and to analyze them adequately. They will know how to deal with pseudoreplicates. |      |          |       |           |
Analytical Competencies

1G assessed
Getting to know the typical properties of financial data and appropriate statistical models, incl. the corresponding functions in R.

2G fostered
- understand the basics of Bayesian inference
- introduction to hierarchical Bayesian models
- R
- introductory statistics
- applied regression

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Method-specific Competencies

447-6289-00L Sampling Surveys

W 2 credits 1G T. Schoch
Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

Abstract
The elements of a sample survey are explained. The most important classical sample designs (simple random sampling and stratified random sampling) with their estimation procedures and the use of auxiliary information including the Horvitz-Thompson estimator are introduced. Data preparation, non-response and its treatment, variance estimation and analysis of survey data is discussed.

Objective
Knowledge of the Elements and the process of a sample survey. Understanding of the paradigm of random samples. Knowledge of simple random sampling and stratified random sampling and capability to apply the corresponding methods. Knowledge of further methods of sampling and estimation as well as data preparation and analysis.

Lecture notes
Introduction to the statistical methods of survey research

447-6201-00L Nonparametric and Resampling Methods

Z 2 credits 2G

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

Abstract
Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.

Objective
For classical parametric models there exist optimal statistical estimators and test statistics whose distributions can often be determined exactly. The methods covered in this course allow for finding statistical procedures for more general models and to derive exact or approximate distributions of complicated estimators and test statistics.

Content
Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.

Prerequisites / notice
This course is part of the programme for the certificate and diploma in Advanced Studies in Applied Statistics. It is given every second year in the winter semester break.

447-6273-00L Applied Bayesian Statistics

W 2 credits 2G S. Robert
Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

Abstract
Introduction to Bayesian statistics: basics of inference, computation with MCMC, linear model, logistic regression, Bayesian hierarchical models. Focus on applications and hands-on programming.

Objective
- understand the basics of Bayesian inference
- use R packages to run MCMC algorithms
- fit and understand Bayesian linear models
- introduction to hierarchical Bayesian models

Content
We will learn how to describe business/scientific problems as probabilistic models, apply Bayes rules to draw inference from data, and use the probabilistic programming language STAN to obtain samples from posterior distributions. We will learn how to build, fit and validate Bayesian models of increasing complexity. There will be examples from various fields: insurance, meteorology, marketing, etc.

Literature
"Bayes Rules! An Introduction to Applied Bayesian Modeling", Alicia A. Johnson, Miles Q. Ott, Mine Dogucu - CRC Press 2022

Prerequisites / notice
- introductory statistics
- applied regression
- R
Analysis of High-Dimensional Data

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

Abstract
Block course on analysis of high-dimensional data with a focus on prediction and feature assessment.

Objective
The goal of this course is to gain a good understanding of the concepts discussed during the lecture and to apply the new methods on real data examples using the software "R". The topics covered in the lecture are:

Part 1: Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization

Part 2: Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

Content
Course on Analysis of High-Dimensional Data with focus on Prediction and Feature Assessment.

Part 1: Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization

Part 2: Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

Lecture notes
The block course is based on lecture notes (https://bookdown.org/staedler_n/highdimstats/).

Literature

Prerequisites / Notice
The exercises are done exclusively with the (free, open source) software "R" (http://www.r-project.org). A final exam will also happen at the computers, using R (and your brains!).

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving fostered
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Spatial Statistics

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

Abstract
In many research fields, spatially referenced data are collected. When analysing such data the focus is either on exploring their structure (dependence on explanatory variables, autocorrelation) and/or on spatial prediction. The course provides an introduction to geostatistical methods that are useful for such purposes.

Objective
The course will provide an overview of the basic concepts and stochastic models that are commonly used to model geostatistical data sets. In addition, the participants will learn a number of geostatistical techniques and acquire some familiarity with software that is useful for analysing spatial data.

Content
After an introductory discussion of the types of problems and the kind of data that arise in environmental research, an introduction into linear geostatistics (models: stationary random processes, modelling large-scale spatial patterns by regression, modelling autocorrelation by variogram; kriging: mean-square prediction of spatial data) will be taught. The lectures will be complemented by data analyses that the participants have to do themselves.

Lecture notes
Slides, descriptions of the problems for the data analyses and worked-out solutions to them will be provided.

Literature
<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
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<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Assessed</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-direction and Self-management</td>
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**CAS in Applied Statistics - Key for Type**

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<tr>
<th>Key for Type</th>
<th>Description</th>
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**Key for Hours**

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**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
CAS in Applied Information Technology

The CAS takes place in Autumn Semester only.

### Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>265-0100-00L</td>
<td>Foundations of Programming</td>
<td>O</td>
<td>2</td>
<td>2A</td>
<td>L. E. Fässler</td>
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</table>

**Abstract**
The initial module offers a practical introduction to some basic concepts and techniques for information processing as well as practical applications of them. The programming language are Python and SQL.

**Objective**
Participants learn...

- how to encode a problem into a program, test the program, and correct errors.
- to understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- query databases and understand and evaluate the corresponding database model.
- to implement mathematical models as a simulation.

**Content**
The following programming concepts are introduced during this module:

1. Variables, data types
2. Condition check, loops, logics
3. Sequential data types
4. Functions and Modules

In the practical part of the course, students work on small programming projects with a context from natural sciences. Electronic tutorials are available as preparation.

**Prerequisites / notice**
No prior knowledge is required for this course. It is based on application-oriented learning. The students spend most of their time working through programming projects and discussing their results with teaching assistants. To learn the programming basics there are electronic tutorials available.

**Competencies**

*Subject-specific Competencies*
- Concepts and Theories
- Techniques and Technologies

*Method-specific Competencies*
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

*Social Competencies*
- Communication
- Cooperation and Teamwork

*Personal Competencies*
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

265-0101-00L | Data Science: From Analytics to Learning | O    | 4     | 3V    | O. Akkus Ispir, E. Konukoglu |

**Abstract**
In this module, basic paradigms and techniques in working with data will be discussed, especially towards data security, managing data decentrally, and learning from data.

**Objective**
Participants will understand some of the concepts in detail and see the mathematics behind them.

**Content**
The module in particular covers cryptography and digital signatures, networking and distributed algorithms, distributed ledger technology, as well as machine learning (supervised and unsupervised learning). For each topic, there will be a hands-on and in-depth introduction that allows participants to gain a technical understanding of key ideas. This is supported by simple and concrete examples as well as programming assignments.

265-0102-00L | Computer Vision Basics | O    | 2     | 2V    | E. Konukoglu |

**Abstract**
This module will cover basic theoretical knowledge on visual recognition systems of the last two decades, mostly focusing on the most recent advancements in deep learning and convolutional neural networks.

**Objective**
Participants understand basic concepts of visual recognition and human-computer interaction systems.

**Content**
The content starts with an introduction to neural networks and then focuses on how they are used for computer vision tasks. The theoretical knowledge will be supported with a practical session that will allow participants to gain hands-on experience with most commonly used tools and deepen their understanding of the key concepts with examples.

265-0104-00L | Reinforcement Learning Basics | O    | 2     | 2V    | B. Grewe |

265-0105-00L | Ethics, Leadership & Communication in Data-Science | O    | 2     | 2V    | O. Akkus Ispir |

### CAS in Applied Information Technology - Key for Type

- **O**: Compulsory
- **W+**: Eligible for credits and recommended
- **W**: Eligible for credits
- **E-**: Recommended, not eligible for credits
- **Z**: Courses outside the curriculum
- **Dr**: Suitable for doctorate
### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>G</th>
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<th>S</th>
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<tbody>
<tr>
<td>lecture</td>
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<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
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<tbody>
<tr>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
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</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Innovation is more than a good idea: It involves bringing the idea to the market, resulting in a highly differentiating market position. Not only fostered Customer Orientation
fostered Lecturers
fostered Communication
Innovation – What Is and to What Purpose Do We
In this module, participants will understand the diverse aspects of these phases and the impact on the organization and governance.

Analytical Competencies
Creative Thinking
fostered

Subject-specific Competencies
fostered

The course provides the framework of organization, managing and reporting of R&D projects and innovation initiatives.

The Innovation Ecosystem

This module wraps up the various aspects of innovation beyond the own organization.

Abstract

The module will be based on a self-study Polybook.

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Problem-solving

Customer Orientation

Creative Thinking

Critical Thinking

In this module, participants will understand the diverse aspects of these phases and the impact on the organization and governance.

In innovation is more than a good idea; It involves bringing the idea to the market, resulting in a highly differentiating market position. Not only product, also ideas have a lifecycle, from conception through launch, scaling, maintenance, to phase out, and replacement by a new innovation. Each phase is facing particular challenges that will be explored.

In most organizations, the R&D organization is the one that delivers the innovation to be brought to the market. In this module, we investigate the inner working of the R&D organization by exploring roles and processes. Since R&D almost always starts with significant uncertainties and unsolved technical problems, governing R&D has to account for these unknowns. As R&D processes take time in which the market environment may change in ways other than predicted at the beginning of a project, external influences have to be continuously monitored as well to enable market success.

The R&D: The Engine of Innovation

The inner working of the R&D organization by exploring roles and processes is investigated.

Objective

The aim of this course is to develop the participants' ability to articulate a coherent plan for R&D activities linked to the business needs of a corporation, and to set the environment to enable an efficient R&D organization.

Content

In most organizations, the R&D organization is the one that delivers the innovation to be brought to the market. In this module, we investigate the inner working of the R&D organization by exploring roles and processes. Since R&D almost always starts with significant uncertainties and unsolved technical problems, governing R&D has to account for these unknowns. As R&D processes take time in which the market environment may change in ways other than predicted at the beginning of a project, external influences have to be continuously monitored as well to enable market success.

The Innovation Ecosystem

This module wraps up the various aspects of innovation beyond the own organization.

Abstract

The goal of this module is to complete the R&D and innovation framework and make the key points available in the context of the organizations' environment.

Content

Successful innovation builds on a whole ecosystem of contributors: customer co-creation, university collaboration, strategic partnerships, or start-up investments are just a few examples of activities where other players may expedite the innovation process. Other aspects of the environment of innovation covers intellectual property strategy, or standardization and certification. In addition to successfully operating in the existing business ecosystem, innovation may transform it, or even create new ecosystems, with innovative business models.

In this module we will look at these various aspects of innovation beyond the own organization. This module will wrap up the CAS and put the material in context of the organization's environment.
### CAS in Applied Technology: R&D and Innovation - Key for Type

<table>
<thead>
<tr>
<th>CAS Type</th>
<th>Description</th>
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<tbody>
<tr>
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<td>W</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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### Key for Hours

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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>268-0101-00L</td>
<td>Introduction to Information Security</td>
<td>O</td>
<td>5</td>
<td>4G</td>
<td>P. Schaller, S. Matetic</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students' understanding of the theory parts.</td>
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<tr>
<td>Objective</td>
<td>Graduates of the course know the technical foundations of information security and understand the difficulty and complexity involved when trying to build secure systems.</td>
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<tr>
<td>Content</td>
<td>In this new course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students' understanding of the theory parts.</td>
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<td>Competencies</td>
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<td>Techniques and Technologies</td>
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<td></td>
<td>Analytical Competencies fostered</td>
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<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
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<tr>
<td>268-0201-00L</td>
<td>Information Security Seminar and Project</td>
<td>O</td>
<td>2</td>
<td>2S</td>
<td>S. Matetic</td>
</tr>
<tr>
<td>Abstract</td>
<td>Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.</td>
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<tr>
<td>Objective</td>
<td>Participants have understood and presented a publication or report on a present topic in information security. By attending other participants presentations students get further introduced to additional current information security related topics/incidents.</td>
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<tr>
<td>Content</td>
<td>Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.</td>
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<tr>
<td>268-0202-00L</td>
<td>Contemporary Topics in Cyber Security</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>S. Matetic</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course is composed of various sub-modules related to Cyber Security taught by experts on the relevant fields.</td>
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<td>Objective</td>
<td>Students are expected to see behind the curtain of current research and engineering activities related to Cyber Security. At the same time students are introduced to contemporary challenges in cyber security by renowned experts.</td>
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<tr>
<td>Content</td>
<td>The lectures cover contemporary aspects and challenges in Cyber Security. The goal is to present current fields of research/engineering and the latest results. By way of example, Cyber Security Policy is one of sub-modules presented by researchers of the Center for Security Studies at ETH. Besides faculty members of the computer science department, there will be guest lecturers from industry presenting Cyber Security related challenges in their field of activity.</td>
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<tr>
<td>Literature</td>
<td>Will be announced during the course.</td>
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### CAS in Cyber Security - Key for Type

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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Introduction to Programming

Abstract
This module offers a practical introduction to some basic concepts and techniques for information processing and their practical applications. The programming languages are Python and SQL.

Objective
Participants learn...
- how to encode a problem into a program, test the program, and correct errors.
- to understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- query databases and understand and evaluate the corresponding database model.
- to implement mathematical models as a simulation.

Content
The following programming concepts are introduced during this module:
1. Variables, data types
2. Condition check, loops, logics
3. Sequential data types
4. Functions and Modules
5. Data management (SQL)

In the practical part of the course, students work on small programming projects with a context from natural sciences. Electronic tutorials are available as preparation.

Prerequisites / notice
No prior knowledge is required for this course. It is based on application-oriented learning. The students spend most of their time working through programming projects and discussing their results with teaching assistants. To learn the programming basics there are electronic tutorials available.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Information, Data & Computers

Abstract
This course provides an introduction to computer science concepts that are foundational for later work in the CAS and MAS programme.

Objective
Students understand fundamental notions of computer science: information, data, computation, programming, algorithm.

Students learn about computers as a concept, how computers fundamentally work, and how this is shaping modern computing infrastructures.

Students can explain the core ingredients of Data Science.

Content
We will cover how information is managed as data, and how we use computers to process data and generate new insights. Concrete questions we will address are: what is data, and how does it represent information? What is a computer, and how does it work? What is a computer program? What is a programming language? What is an algorithm? What is the role of AI in computer programming? What kind of computer systems do we have today, and why? What is Data Science?

Through this, we will build a fundamental understanding of how computer and data science enable today's information society.

Literature
Slides and links to extra material will be distributed during the course.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Data Science & Machine Learning

Abstract
This course provides a fundamental training in the areas of data science and machine learning. It is intended for managers and leaders who want to understand the typical workflow, fundamental techniques and key challenges of data science and machine learning to drive successful implementations.
Objective
After taking this course the participants
- have a good understanding of the basic methods of data science and machine learning
- know the typical data science workflow and can understand and assess the role and importance of each individual step
- understand the importance of quantifying and communicating uncertainty in the data
- know the importance and basic techniques of cleaning and organizing data and can perform simple data cleaning tasks in pandas.
- can identify suitable algorithms and select the best-suited one for a given task
- can apply machine learning methods as implemented in scikit-learn on tabular data
- understand the basic ideas behind modern deep learning methods and can implement simple deep learning models in tensorflow
- understand some key applications such as natural language processing or computer vision.
- are able to apply the learned methods to practical problems in data science.

Content
We will cover the following topics
- The typical data science workflow
- Cleaning, organizing and preparing data for further analysis
- Exploratory data analysis: Gaining an understanding through visualizing and summarizing data
- Basics of statistical inference and uncertainty quantification
- Correlations and regression.
- Basics of Machine learning, including supervised and unsupervised learning, model evaluation and model selection
- Standard algorithms such as linear regression, decision trees, k-nearest neighbors, k-means, principal component analysis
- Identification of the best-suited algorithm and models for a given dataset and machine learning task
- Foundations of Deep Learning
- Challenges & Considerations: Potential pitfalls, threats, and ethical considerations.

The theoretical parts will be complemented by practical exercises using python, pandas, numpy, matplotlib, scikit-learn, and tensorflow.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered
Social Competencies
Communication fostered
Cooperation and Teamwork assessed
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered

275-0004-00L  AI and IT in Industry  O  3 credits  2V

Abstract
Participants learn how new information technologies such as machine learning and AI change different aspects of a business, and learn how to evaluate specific risks, costs, and benefits of new technologies. It addresses success factors and pitfalls for technology initiatives, and equips participants to contribute to technology-related decisions.

Objective
Participants understand how technology impacts business strategy. They are able to assess benefits, costs, and risks of new technology use, and to contribute to decisions balancing these aspects. They understand the long-term impact of today's technology decisions and can use it to help companies make better technology investment decisions.

Participants are able to confidently participate in discussions with technical experts and to ensure technology is evaluated from the perspective of the commissioning business.

Participants understand how AI projects differ from traditional IT projects. They are able to shape respective projects in their companies and to help make them successful.

Content
This integration module links the newly acquired understanding of technology with technology’s impact on business strategy. Participants will explore how new information technologies such as machine learning and AI change different aspects of a business, and learn how to evaluate specific risks, costs, and benefits of new technologies. The module will shed light on success factors and common pitfalls when implementing new technologies and respective business changes, and it will specifically address the communication between technical experts and business management. The module provides insights into how participants can contribute to technology-related decisions and help shape the use of IT for business benefit. It teaches concepts regarding IT cost, IT risk, IT complexity, and IT lifecycle management, software architecture and project methodologies, including how machine-learning projects differ from traditional IT projects, and applies them to a number of current business/IT topics such as cloud computing, use of AI for software development, and Internet of Things.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Self-presentation and Social Influence assessed
Personal Competencies
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics assessed
### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
- European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Digital Health

Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>375-0003-00L</td>
<td>Designing a Digital Biomarker (Group Project 2)</td>
<td>4</td>
<td>1G</td>
<td>M. Jovanova, T. Kowatsch</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>The course introduces the concept of digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) can meet the health monitoring needs of the world's aging population and the ever-growing number of chronic patients. However, this premise is based on applying information and communication technologies that allow us to monitor patient data in many different ways. In this course, we will analyze systematic ways to collect data, review the most appropriate methods and applications in healthcare, discuss the main challenges, and apply the newly gained knowledge in a project.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>The course will cover the following topics:</td>
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<tr>
<td></td>
<td>1. Introduction to digital biomarkers</td>
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<td></td>
<td>2. Design of digital biomarker studies</td>
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<td></td>
<td>3. Exploration and assessment of digital biomarker candidates</td>
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<td>4. Digital biomarker project and critical reflection</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td></td>
<td>This module is assessed based on the participant's pass/fail status of the group project (including a presentation). The group project is ungraded.</td>
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<td></td>
<td><strong>Competencies</strong></td>
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<tr>
<td></td>
<td><strong>Subject-specific Competencies</strong></td>
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<tr>
<td></td>
<td>1. Methods and Technologies</td>
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<td>2. Adaptable and Flexible</td>
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<td></td>
<td>3. Adaptability and Flexibility</td>
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<td></td>
<td>4. Critical Thinking</td>
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<td><strong>Method-specific Competencies</strong></td>
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<td></td>
<td>1. Communication</td>
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<td>2. Negotiation</td>
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<td></td>
<td>3. Sensitivity to Diversity</td>
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<td></td>
<td>4. Problem-solving</td>
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<td></td>
<td><strong>Social Competencies</strong></td>
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<tr>
<td></td>
<td>1. Communication</td>
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<td>2. Cooperation and Teamwork</td>
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<td></td>
<td>3. Customer Orientation</td>
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<td>4. Leadership and Responsibility</td>
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<td></td>
<td><strong>Personal Competencies</strong></td>
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<td></td>
<td>1. Adaptability and Flexibility</td>
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<td></td>
<td>2. Critical Thinking</td>
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<td></td>
<td>3. Integrity and Work Ethics</td>
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<td></td>
<td>4. Self-awareness and Self-reflection</td>
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<td><strong>Lecturers</strong></td>
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Designing a Just-in-time Adaptive Intervention (Group Project 3)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
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<tr>
<td>375-0004-00L</td>
<td>Designing a Just-in-time Adaptive Intervention (Group Project 3)</td>
<td>4</td>
<td>2G</td>
<td>M. K. Nißen, T. Kowatsch</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Today, we face the challenge of chronic conditions. Personal coaching approaches are neither scalable nor financially sustainable. The question arises therefore to which degree Digital Health Interventions (DHIs) are appropriate to address this challenge. In this CAS module, students will design, implement and evaluate a DHI, esp. a just-in-time adaptive intervention.</td>
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</table>
After this module, participants will be able to…

1. understand the importance of just-in-time adaptive interventions (JITAIs), esp. for the prevention of NCDs
2. understand the design, implementation and evaluation of smartphone-based and chatbot-delivered JITAIs
3. discuss opportunities and challenges of JITAIs

"Can medical Alexas make us more healthy?" (The New York Times, April 2021); "Wearables as a tool for measuring therapeutic adherence in behavioral health" (npj Digital Medicine, May 2021); "Improving community healthcare screenings with smartphone-based AI technologies" (The Lancet Digital Health, May 2021); "Predictive analytics and tailored interventions improve clinical outcomes" (npj Digital Medicine, June 2021); "H1 2021 secured $14.7B in digital health funding, already surpassing all of 2020's funding" (Rock Health, 2021)

What are the implications and rationale behind the recent developments in the field of digital health?

Digital Health is the use of information and communication technology for the prevention and treatment of diseases in the everyday life of individuals. It is thus linked to topics such as digital health interventions, digital biomarkers, digital coaches and healthcare chatbots, telemedicine, mobile and wearable computing, self-tracking, personalized medicine, connected health, smart homes, or smart cars.

In the 20th century, healthcare systems specialized in acute care. In the 21st century, we now face the challenge of dealing with the specific characteristics of non-communicable diseases (NCDs). NCDs are now responsible for around 70% of all deaths worldwide and 85% of all deaths in Europe and are associated with an estimated economic loss of $7 trillion between 2011 and 2025. NCDs are characterized in particular by the fact that they require an intervention paradigm that focuses on prevention and lifestyle change. Lifestyle (e.g., diet, physical activity, tobacco, or alcohol consumption) can reduce the risk of suffering from a chronic condition or, if already present, can reduce its burden. A corresponding change in lifestyle is, however, only implemented by a fraction of those affected, partly because of missing or inadequate interventions or health literacy, partly due to socio-cultural influences. Individual personal coaching of these individuals is neither scalable nor financially sustainable.

To this end, the question arises on how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, behavioral medicine, information systems research, and computer science, this CAS module has the objective to help participants interested in the multi-disciplinary field of digital health to better understand the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions (JITAIs).

After this module, participants will be able to…

1. understand the importance of JITAIs, esp. for the prevention of NCDs
2. understand the design, implementation and evaluation of smartphone-based and chatbot-delivered JITAIs
3. discuss opportunities and challenges of JITAIs

The CAS module is structured in two parts and follows the concept of a blended treatment consisting of live sessions and complementary online material. In the live sessions, participants will learn relevant topics. Complementary learning material (e.g., video clips), multiple-choice questions, and exercises are provided via the online learning platform.

In the second part, participants work in teams and will use their knowledge from the first part of the module to develop a smartphone-based and chatbot-delivered JITAI with MobileCoach (www.mobile-coach.eu), an open-source software platform for the development of digital biomarker and digital health interventions. Each team will then present and discuss the resulting JITAI and evaluation results with their colleagues who will provide peer reviews. Additional live coaching sessions are offered to support the teams with the design and evaluation of their JITAI and with the preparation of the final group project presentations.

Literature
### Competencies

<table>
<thead>
<tr>
<th>Sub-category</th>
<th>Competencies</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories assessed</td>
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</tr>
<tr>
<td></td>
<td>Techniques and Technologies assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies assessed</td>
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<td></td>
<td>Decision-making assessed</td>
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<td></td>
<td>Media and Digital Technologies assessed</td>
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<td></td>
<td>Problem-solving assessed</td>
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<td></td>
<td>Project Management assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication assessed</td>
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<td></td>
<td>Cooperation and Teamwork assessed</td>
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<td></td>
<td>Customer Orientation assessed</td>
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<td></td>
<td>Leadership and Responsibility assessed</td>
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<td></td>
<td>Self-presentation and Social Influence assessed</td>
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<td></td>
<td>Sensitivity to Diversity assessed</td>
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<td>Negotiation assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility assessed</td>
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<td></td>
<td>Creative Thinking assessed</td>
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<td></td>
<td>Critical Thinking assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection assessed</td>
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<td></td>
<td>Self-direction and Self-management assessed</td>
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### CAS in Digital Health - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>W+ Eligible for credits and recommended</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>W Eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E- Recommended, not eligible for credits</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

**ECTS**
- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
# CAS in Digital Clinical Trials

## Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>395-0100-01L</td>
<td>The Power of Study Design</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>S. Goldhahn, A. Burden, D. Stekhoven, to be announced</td>
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<tr>
<td>395-0103-00L</td>
<td>Precision Medicine and AI</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>A. Fontecedro-Curioni, A. Ghosh, S. Modica</td>
</tr>
</tbody>
</table>

### Abstract

Precision Medicine is a new approach in health care aiming to deliver personalized prevention and treatment for human diseases, by taking into account individual differences in lifestyle, environment, and biology.

### Objective

After taking this course, participants will be able:

- to describe the goal of precision medicine;
- to explain different next-generation sequencing technologies;
- to illustrate how to make good use of public biological/clinical repositories;
- to demonstrate basic concepts of big data and machine learning;
- to explain how to genotype biological samples for a genetic disease;
- to describe examples of complicated ethical or clinical situations in personalized medicine.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>395-0104-00L</td>
<td>Digital Measures</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>J. Goldhahn, I. Clay</td>
</tr>
</tbody>
</table>

### Abstract

Participants will learn all necessary steps to establish new digital measures for their own clinical research. They will get a comprehensive understanding of this new emerging field, will discuss the newest guidelines with authors from international societies, will have a chance to interact with digital pioneers, and will be enabled to develop a concept for their individual digital measure.

### Objective

The course enables participants to:

1. describe why new methods are needed to generate evidence.
2. describe how new (digital) methods for generating evidence are established.
3. explain how the concept of patient-centredness is applied in the development of new methods for evidence generation.
4. analyse sources of bias in basic research.
5. analyse the conditions for the development and validation of new evidence generation tools.
6. understand the framework for the development of new methods for evidence generation and to analyse the advantages and disadvantages of different approaches.
7. develop their own concept for a new digital measure.

### Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Assessed</th>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Assessed</th>
<th>Decision-making</th>
<th>Fostered</th>
<th>Media and Digital Technologies</th>
<th>Assessed</th>
<th>Problem-solving</th>
<th>Assessed</th>
<th>Project Management</th>
<th>Fostered</th>
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<tbody>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>Fostered</td>
<td>Cooperation and Teamwork</td>
<td>Fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>Fostered</td>
<td>Critical Thinking</td>
<td>Fostered</td>
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### CAS in Digital Clinical Trials - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
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</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</tbody>
</table>

### Key for Hours

| V    | lecture                                         |
| G    | lecture with exercise                           |
| U    | exercise                                        |
| S    | seminar                                         |
| K    | colloquium                                      |
| P    | practical/laboratory course                     |
| A    | independent project                             |
| D    | diploma thesis                                  |
| R    | revision course / private study                 |

### ECTS

- European Credit Transfer and Accumulation System

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CAS in Entrepreneurial Leadership in Technology Ventures

Start: Every Autumn Semester

Duration: 12 months. It is possible to join the programme at the beginning of each semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>373-0100-00L</td>
<td>Entrepreneurial Strategies</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>B. Clarysse</td>
</tr>
<tr>
<td>Abstract</td>
<td>This is the first knowledge module in the CAS ELTV. In this module we (1) introduce all participants to the CAS and ETH, (2) get to know in more detail the projects of the participants and how lean innovation plays a role, and (3) discuss important considerations of strategy formation in technology ventures.</td>
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<tr>
<td>Objective</td>
<td>This module enables participants:</td>
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<td></td>
<td>- To understand and select from commercialization strategies available to them (e.g., licensing, partnering, and vertical integration) and respective business model choices</td>
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<td>- Assess and generate development options for key internal enabling factors such IP strategy and key resources and capabilities</td>
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<td>- Understand different market research and developments tools (lean start-up vs. technology broadcasting) and select appropriate methods and related KPIs</td>
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<tr>
<td>Content</td>
<td>This module focuses on elements of entrepreneurial strategy formation and implementation in nascent markets and/or industries. Participants will study commercial options available to them, e.g., technology broadcasting, licensing and partnering, and vertical integration, which is complemented by a practical view on IP strategy, driven by business strategy rather than arbitrary choices. The module also includes the introduction to lean innovation methods incl. agile product development methods and core tools of the lean startup approach.</td>
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<tr>
<td>Lecture notes</td>
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<tr>
<td>Literature</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This module is only for CAS ELTV participants.</td>
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</table>

| 373-0101-00L| Entrepreneurial Leadership and Teams | O    | 2    | 2G    | J. Thiel, L. P. T. Vandeweghe |
| Abstract    | This is the second knowledge module within the CAS ELTV. During this module, we will discuss important themes concerning entrepreneurial team formation and management and practice elements in interactive workshops. The module will be extended by intermediary project review meetings. |
| Objective   | This module enables participants:  |
|             | - To understand key requirements for new venture leadership and how to build effective governance structures for the founding team |
|             | - To select and implement approaches and methods to structure productive work relationships within an emerging firm. |
|             | - To understand and build the organizational foundations for successful venture operations |
| Content     | This module zooms in on the design and management of new venture teams in technology- based companies as well as the role of leadership in building successful venture teams. Key contents in this module comprise founder contracts, successful governance structures, and approaches to team performance management. This module also allows participants to understand requirements for venture leadership and professionalizing venture operations as well as building productive work relationship within their emerging firm. |
| Lecture notes | See Online Platform               |
| Literature  | See Online Platform               |
| Prerequisites / notice | This module is for CAS ELTV participants only. |

| 373-0102-00L| Entrepreneurial Marketing and Sales | O    | 1    | 2G    | M. Gruber, B. Clarysse |
| Abstract    | This is the third knowledge module within the CAS ELTV. During this module, we will discuss important themes concerning entrepreneurial team formation and management and practice elements in interactive workshops. The module will be extended by intermediary project review meetings. |
| Objective   | This module enables participants:  |
|             | - To understand customer needs and the respective markets |
|             | - To practice and optimize successful communication with and towards existing and future customers (e.g., strategic selling, key account management, communication tools) |
|             | - To understand and use different pricing techniques for technology products and services, both in B2C and B2B contexts. |
|             | - To select appropriate strategies to build up effective sales channels and calculate and optimize respective funnel KPIs and assess the implications on the venture's business model and organization (e.g., lead management, funnel metrics, etc.) |
| Content     | This module exposes participants to important customer development and market research strategies, with the goal to build competencies in several customer-facing activity domains of the growing venture. Key module themes span the pricing of technology products and services, both in B2C and B2B contexts, the effective build-up of sales channels and funnels, and the successful communication to existing as well as future customers. |
| Lecture notes | See Online Platform               |
| Literature  | See Online Platform               |
| Prerequisites / notice | This module is for CAS ELTV Participants only. |

| Abstract    | This module focuses on the development needs for participants' business skills and competencies. Experienced business coaches and mentors will interact regularly with participants, offer guidance on how to strategize and implement business cases. They will give feedback on challenges and activities and help participants strengthen their abilities to garner needed resources for their undertakings. |
| Objective   | This module enables participants:  |
|             | - To identify key unknowns and important progress measures for their respective business case and implement effective means and tools to further develop their business case |
|             | - To understand the view of potential customers and implement their feedback to improve the business case |
|             | - To effectively communicate and enrol other important venture constituents (mentors, advisors, employees, investors, etc.) in the venture. |
| Content     | This module focuses on the development needs of participants' business skills and competencies. In this module, experienced business coaches and startup mentors will interact regularly with the participants, offer guidance on how to strategize and implement compelling business cases, feedback on specific challenges, and participants' activities with the goal to strengthen the ability of the participant to garner needed resources for their undertakings. |
| Lecture notes | See Online Platform               |
| Literature  | See Online Platform               |
| Prerequisites / notice | This module is for CAS ELTV participants only. |

| 373-0201-00L| Leadership Development | O    | 1    | 2P    | B. Clarysse |
| Abstract    | This module is only for CAS ELTV participants. |

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 460 of 2667
Abstract
This module focuses on the development needs for participants' leadership competencies. In this module, experienced leadership coaches will interact regularly with the participants, coach along a personal development plan, and feedback on specific challenges and participants' activities with the goal to strengthen the participants' leader capability and people skills.

Objective
This module enables participants:
- To identify current gaps in the personal management skills and competencies and develop meaningful goals and plans to fill those gaps
- To implement effective exercises and practices to improve the participants' leadership capacity
- To effectively communicate and manage key constituents, notably employees and key advisors in a venture project.

Content
This module focuses on the development needs of participants' leadership competencies. In this module, experienced leadership coaches will interact regularly with the participants, coach them along a personal development plan, and feedback participants on specific challenges and activities with the goal to strengthen the participants' leadership capability and people skills.

Lecture notes
See Online Platform

Literature
See Online Platform

Prerequisites / notice
This module is only for CAS ELTV participants.

CAS in Entrepreneurial Leadership in Technology Ventures - Key for Type

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<th>Key</th>
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Key for Hours

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<td>practical/laboratory course</td>
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<td>revision course / private study</td>
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ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

Autumn Semester 2024
### CAS in Global Cooperation and Sustainable Development

Take place each spring semester and every second autumn semester (odd years).

<table>
<thead>
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<th>Number</th>
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</table>

Abstract

The course aims at strengthening the capacity in portfolio management for VET, skills development and active labor market policies. It deals with basic issues and challenges of Vocational Education and Training (VET) in Developing Countries. In view of the many of school leavers VET has to place itself between the contradicting intensions of quality education and short-term training interventions.

Objective

The participants are able to
- Assess project proposals and ongoing project regarding their relevance and suitability in the specific country context
- Explain strengths and weaknesses of the opposing approaches “dual apprenticeship” and “competency based training” as well as synergies and incompatibilities between the two
- Describe the competent use of tools currently applied in VET

Content

- Basic concepts and terms
- Differences and commonalities between VET and neighboring systems
- Planning, assessment of VET interventions with different objectives: economic development, poverty alleviation, creation of self-employment or systems development
- VET as a cooperation system of stakeholders with different duties, interests and competencies
- Background, potential use and limitations of (national) qualification frameworks
- Half-day visit to important actors of the Swiss VET landscape

Prerequisites / notice

Students of the course must fulfill requirements specified on the homepage of NADEL.

<table>
<thead>
<tr>
<th>Competencies</th>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork fostered</td>
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<td>Self-presentation and Social Influence fostered</td>
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<td>Sensitivity to Diversity fostered</td>
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<td>Personal Competencies</td>
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<td>Self-awareness and Self-reflection fostered</td>
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</table>

Abstract

The course provides a deeper understanding of the methodological foundations of results-oriented planning and steering of development projects. Together with the participants, we reflect on the situation-specific application of instruments for project planning and the development of a monitoring system, which makes it possible to adapt and steer projects.

Objective

The course participants are able to describe the processes and concepts of project planning and monitoring using the correct technical terminology, to initiate an analysis of the initial situation, to elaborate a monitoring system, and to adaptively steer the implementation of projects.

Content

- Basic concepts of result-oriented project management
- Instruments and resources for project planning, including the elaboration of a "logframe matrix" and results chain
- 24 months of resources for project monitoring, and for the development of a monitoring system, including indicators to assess objectives achievement and steer the Project
- 'Write' and structure results-oriented Project reports

Prerequisites / notice

Students of the course must fulfill requirements specified on the homepage of NADEL.

<table>
<thead>
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</table>
Qualitative and Participatory Research Methods for Development Practitioners

**Abstract**
This course draws out good practices in promoting sustainability development at the city level. Participants gain insights on designing urban-focused development interventions.

**Objective**
Historically, cities have been hubs of innovation, economic activity and rising prosperity. However, the unprecedented speed and scale at which cities are growing today is a huge challenge. As epicenters of migration, environmental degradation, health hazards and unemployment, urban areas are especially vulnerable to disasters, social conflict and inequality. Despite this, some of the most promising initiatives to achieve the SDGs have been implemented by cities. What strategies and processes do successful city-based initiatives pursue? How can development organisations support mainstreaming the SDGs at the local level? What can be learnt from experiences so far? This course draws out good practices in promoting sustainability and equity at the city and local level. Participants gain insights on designing urban-focused development interventions.

**Content**
Key Topics:
- Drivers, dynamics and challenges of urbanization
- The urban-rural continuum – why does it matter?
- Localisation of global development and sustainability agendas: challenges and opportunities
- Three to four case studies selected from the following: informal settlements, urban food systems, WASH, children’s well-being, circularity, migration.

**Prerequisites / notice**
Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with the NADEL secretariat.

**Competencies**

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Does not take place this semester.
Only for MAS/CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

**Registration only through the NADEL administration office.**

Engaging with Policy Processes: Strategies and Tools

**Abstract**
Qualitative research has much to offer to the practical work of development organizations. This course will provide an overview of the principles and practice of qualitative research and illustrate ways in which qualitative research can be incorporated into the programme cycle. Participants will learn to collect and analyse data, using qualitative methods.

**Objective**
The course aims to demystify qualitative research and build the skills of development practitioners in using qualitative methods confidently, and to communicate findings to different audiences.

**Content**
- The qualitative research approach.
- Qualitative research methods, including interviews, focus group discussions and participant observation.
- Designing and planning qualitative studies.
- Qualitative data analysis and interpretation.
- Reporting of qualitative results.
- Embedding qualitative research within a project cycle.

**Prerequisites / notice**
Targeting students doing a CAS in Development and Cooperation

<table>
<thead>
<tr>
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Only for MAS/CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

**Registration only through the NADEL administration office.**

Migration and Development

**Abstract**
This course draws out good practices in promoting sustainability development at the city level. Participants gain insights on designing urban-focused development interventions.

**Objective**
Historically, cities have been hubs of innovation, economic activity and rising prosperity. However, the unprecedented speed and scale at which cities are growing today is a huge challenge. As epicenters of migration, environmental degradation, health hazards and unemployment, urban areas are especially vulnerable to disasters, social conflict and inequality. Despite this, some of the most promising initiatives to achieve the SDGs have been implemented by cities. What strategies and processes do successful city-based initiatives pursue? How can development organisations support mainstreaming the SDGs at the local level? What can be learnt from experiences so far? This course draws out good practices in promoting sustainability and equity at the city and local level. Participants gain insights on designing urban-focused development interventions.

**Content**
Key Topics:
- Drivers, dynamics and challenges of urbanization
- The urban-rural continuum – why does it matter?
- Localisation of global development and sustainability agendas: challenges and opportunities
- Three to four case studies selected from the following: informal settlements, urban food systems, WASH, children’s well-being, circularity, migration.

**Prerequisites / notice**
Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with NADEL secretariat.

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Does not take place this semester.
Only for MAS/CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.
24 months of practical experience in international cooperation.

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

ETH MA/MSc students apply with a letter of motivation to the NADEL administration office.

Registration only through the NADEL administration office.

Abstract
Globally, over 280 million people live outside their countries of origin. While the concept of migration has negative connotations for some, migration can bring significant benefits – to both countries of origin and destination, if the right policies and initiatives are in place. The course explores the role that international cooperation can play in promoting the positive aspects of migration.

Objective
Course participants have improved understanding of the following issues:
- Definition of migration concepts and terms
- International legal frameworks related to migration
- The geography of migration flows
- Major drivers of migration
- The evolving concept of “migration and development”
- International cooperation organisations and their strategies and activities in terms of migration and development.

Content
Globally, over 280 million people are currently living outside their countries of origin, voluntarily and involuntarily; and a further 60 million people live in internal displacement settings within their countries of origin. Migration is multifaceted, and driven by various, often interlinked factors including conflict and violence, economic, social and political factors, as well as environmental and climate related events. While the concept of migration has negative connotations for some, migration can bring significant benefits – to both countries of origin and destination; if the right policies and initiatives are in place. The course explores the role that international cooperation can play in promoting the positive aspects of migration and in reducing the potential negative consequences.

This course covers:
- Important terms and concepts related to migration;
- International legal frameworks related to migration;
- The geography of migration flows;
- Major drivers of migration;
- The evolving concept of migration and development;
- Actions, strategies and initiatives of international cooperation actors when it comes to migration and development.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Cooperation and Teamwork fostered
- Critical Thinking fostered

865-0020-00L Social Entrepreneurship – Driving Sustainability in Business

Does not take place this semester.

Only for MAS/CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

Registration only through the NADEL administration office.

Abstract
This course introduces the concept of social entrepreneurship, understanding in which situations and under which conditions the concept can be applied, and the basics of developing a business strategy for a social enterprise.

Objective
This course introduces the concept of social entrepreneurship over three different blocks. The first part is dedicated to the definition, history, context and the successes and blockers of social entrepreneurship, including some real-world examples. In the second part the participants will learn to transform a social business idea into a concrete social business plan. The last block of the course is dedicated to the power of storytelling, where participants learn how to pitch their business ideas convincingly.

Content
- Definitions of “social entrepreneurship” and the difference with “entrepreneurship”
- Get inspired by concrete examples of successful social ventures
- Formulate a social business plan using the business canvas methodology
- Learning to think and act like a social entrepreneur
- The art and power of storytelling in an entrepreneurial context

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Decision-making assessed
- Customer Orientation assessed

865-0059-00L Storytelling for Systems Change

Only for CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

Registration only through the NADEL administration office.
Abstract
This course provides a foundation in the principles, techniques, and strategies for storytelling in the context of systems change. Key topics include:
- Psychology of Stories
- Key Elements and Techniques of Storytelling
- Ethics & Authenticity
- Using Stories in Project Cycle Management

Objective
By the end of this course, participants will be able to apply and adapt the fundamentals of storytelling to support their work as development practitioners and as proponents of systems change. They will be able to integrate storytelling techniques into activities such as reporting, fundraising, and context analysis. They will be better equipped to construct stories that are engaging and illustrative of the complexity of systems change.

Competencies
<table>
<thead>
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865-0049-00L AI for Global Development Organisations
W 1 credit 1G I. Günther
Only for CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.
ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.
Registration only through the NADEL administration office.

865-0012-00L Gender and Economics
W 3 credits 3G M. Malefakis
Only for MAS/CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.
ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.
ETH MA/MSc students apply with a letter of motivation to the NADEL administration office.
Registration only through the NADEL administration office.

Abstract
This course on gender and economics is intended to provide basic- and intermediate-level training to development practitioners and policy and program staff in international development agencies. Economic inequalities between men and women persist in many countries. For example, in many countries, men earn more money and are more likely to own land and control productive assets than women. This course on gender and economics is intended to provide basic- and intermediate-level training to development practitioners and policy and program staff in international development agencies. The overall objective of the course is to strengthen the capacity of technical advisors and program staff on the importance of gender-responsive economic policy. The course is taught in cooperation with SDC and UN women.

CAS in Global Cooperation and Sustainable Development - Key for Type

<table>
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Key for Hours

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ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
Historic buildings and sites are not per se significant parts of cultural heritage. They only become so when certain values are associated with them. Monument values are as dynamic as the society that produces them. The lecture traces the historical development of monument recognition and preservation in Switzerland since 1798. Monument values are not only important for preserving and maintaining such objects, but also for building owners. Monument values are also important for architects, the real estate industry, or property owners. Monument values are recognized and preserved within different levels. In addition to classic protection criteria, ecological and economic considerations, too, must be taken into account.

In the past two decades witnessed significant advances in the areas of computational design and digital fabrication in architecture. These innovations embedded in such objects offer a preview to building methods which will become commonplace in the production of buildings in the future. The 20th century is often considered unattractive and its maintenance or upgrading a costly imposition. However, it is precisely this stock that holds great potential, as it generally allows more possibilities for use and change than protected objects. In case of demolition, individual components of these buildings can possibly be reused.

The discussion about values, protection and preservation of the existing building stock is complex and must be conducted on different levels. In addition to classic protection criteria, ecological and economic considerations, too, must be taken into account.

This course focuses on recent constructions built using innovative computational design and fabrication technologies, and the challenges associated with their repair, maintenance, and preservation.

With the help of input lectures and excursions in and around Zurich, participants will explore new types of materials, structural designs, and the challenges associated with their repair, maintenance, and preservation. The students of this seminar will gain insight into different evaluation criteria and value systems within the larger field of preservation. While buildings protected as monuments are widely recognized as cultural heritage, the large building stock of the second half of the 20th century is often considered unattractive and its maintenance or upgrading a costly imposition. However, it is precisely this stock that holds great potential, as it generally allows more possibilities for use and change than protected objects. In case of demolition, individual components of these buildings can possibly be reused.

This course discusses the role and relevance of digitally built architecture as heritage through excursions and input lectures. The discussion will be accompanied by a critical observation on the existing preservation theories and practices regarding innovations in the field of digital fabrication in architecture. This course will discuss the role and relevance of digitally built architecture as heritage through excursions and input lectures. The discussion will be accompanied by a critical observation on the existing preservation theories and practices regarding innovations in the field of digital fabrication in architecture.

In the MAS/CAS seminar, we will critically discuss values and meanings relevant within the field of architecture. This will be done by examining and comparing the values of buildings as well as evaluation criteria of various actors – such as preservation authorities, architects, the real estate industry, or property owners.

The discussion about values, protection and preservation of the existing building stock is complex and must be conducted on different levels. In addition to classic protection criteria, ecological and economic considerations, too, must be taken into account.
Objective

Students will be able to name the most important actors in Swiss heritage conservation and describe developments in the field. They know methodological approaches and can place them in their historical context. They can identify the necessary principles and instruments in different situations and use them in their professional environment.

Content

In the 20th century, the most important impulses for the theory and practice of restoration came from the Federal Commission for the Preservation of Monuments, whose theoretical discourse and work are traced in detail. However, the activities of the cantons, private-law organisations and universities are also examined within the course. The institutionalisation of monument preservation is analysed in the context of social developments, whereby the evolution of its self-image from a patriotic civic duty in the age of industrialisation to monument preservation as environmental protection in the sustainability discourse of the 21st century is also examined. In the second half of the semester, the theoretical foundations, actors and instruments that are relevant in Switzerland today will be presented and their interaction explained.

Central questions will be examined in greater depth using concrete case studies. Among others, the following will be discussed: the restoration of Chillon Castle from 1897; the mountain village restoration of Vrin in 1944; the restoration of the Augustinian Church in Zurich in 1958; the controversy surrounding the reconstruction of the Predigerchor in Zurich in 1987; the extension of the Stadtcasino Basel (2016-2020); the struggle for the preservation of medieval wooden buildings in the canton of Schwyz (2000-2021).

Competencies

Subject-specific Competencies

Concepts and Theories fostered

Development of the Existing Building Stock

079-0252-00L

Abstract

The course deals with the densification strategy of the city of Zurich and the resulting handling of existing building stock (mostly demolition and new construction). Insights into real estate evaluation and specific examples are used to show possible alternatives.

Objective

The course discusses the topic of densification and the future of the existing building stock. By dealing with the qualities of existing buildings within the areas to be densified, students are invited to discuss whether these objects are to be preserved, transformed, and supplemented or whether they have to be demolished.

Content

The city of Zurich introduced the densification strategy in the revised spatial planning law, focusing on the existing building stock. As a rule, densification is achieved today through demolitions and replacement. This includes buildings which are still in a good condition. The course thus aims to explore possible alternatives.

Brief general introduction to the real estate market and real estate valuation; introduction to the topic of "densification", well and badly realised examples; discussion of current densification projects and alternative solutions within the framework of two to three workshops.

Competencies

Subject-specific Competencies

Concepts and Theories fostered

Method-specific Competencies

Analytical Competencies fostered

Decision-making fostered

Problem-solving fostered

Project Management fostered

Social Competencies

Communication fostered

Cooperation and Teamwork fostered

Customer Orientation fostered

Leadership and Responsibility fostered

Negotiation fostered

Personal Competencies

Creative Thinking fostered

Critical Thinking fostered

CAS in Future Heritage - Key for Type

O Compulsory

W+ Eligible for credits and recommended

W Eligible for credits

Key for Hours

V lecture

G lecture with exercise

U exercise

S seminar

K colloquium

P practical/laboratory course

A independent project

D diploma thesis

R revision course / private study

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## CAS in Geoinformation Systems and Analysis

### Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>148-0001-00L</td>
<td>GIS-basics and -principles</td>
<td>O</td>
<td>3 credits</td>
<td>4G</td>
<td>L. Hurni, M. Raubal</td>
</tr>
<tr>
<td>Abstract</td>
<td>A Geographic Information System (GIS) is a system for collecting, managing, analyzing and visualizing spatial data (geodata). This module teaches the fundamental concepts and principles necessary for a comprehensive understanding and effective application of GIS technologies.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>After completion of this module, students will be able to understand the fundamentals of Geographic Information Systems (GIS) and be able to retrieve and apply them appropriately in practice. They will be able to describe and apply the essential components and principles of GIS.</td>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>148-0002-00L</td>
<td>GIS-methods and processes</td>
<td>O</td>
<td>4 credits</td>
<td>7G</td>
<td>L. Hurni, M. Raubal</td>
</tr>
<tr>
<td>Abstract</td>
<td>GIS methods and processes represent the basic strategies and processing steps used within a GIS workflow to model, capture, manage, analyze, and visualize geodata. The GIS workflow is a systematic approach that ensures that geospatial data is used effectively to solve problems in various application domains.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The aim of this module is to provide students with a comprehensive understanding and diverse skills in the use of GIS methods and processes. The entire sequence of geodata processing from acquisition to application is to be covered. The goal is to provide students with a structured and systematic approach to effectively process and use geospatial data in a meaningful way.</td>
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</table>

### Project

Offered in the spring semester

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**CAS in Geoinformation Systems and Analysis - Key for Type**

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Focus Courses and Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
</tbody>
</table>

**Abstract**

Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection.

**Objective**

- After this course, students will:
  - Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
  - Be able to reason about language concepts on a semantic level and be able to compare and evaluate language designs.
  - Be able to learn new languages more rapidly.
  - Be aware of many subtle problems of object-oriented programming and know how to avoid them.

**Content**

The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:

- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
- The key problems of single and multiple inheritance and how different languages address them
- Generic type systems, in particular, Java generics, C# generics, and C++ templates
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing
- How to maintain the consistency of data structures

**Literature**

- Will be announced in the lecture.
- Prerequisites: Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

### Prerequisites / notice

**Literature**

- Will be announced in the lecture.
- Prerequisites: Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0293-00L</td>
<td>Wireless Networking and Mobile Computing</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>S. Mangold</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.

**Objective**

- The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own add-on mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator.
- We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.

**Content**

Wireless Communication, Wi-Fi, Contact Tracing, Bluetooth, Internet-of-Things, 5G, Standards, Regulation, Algorithms, Radio Spectrum, Cognitive Radio, Mesh Networks, Optical Communication, Visible Light Communication. We will address contact tracing, radio link budget, location distance measurements, and Bluetooth in more depth. MedTech basics are also provided.

Chapters:

1. Introduction
2. Wireless Communication Basics
3. IEEE 802.11 Wireless LAN (Wi-Fi)
4. IEEE 802.15 Wireless PAN (ZigBee & Bluetooth)
5. Mobile Computing Algorithm Basics: Control and Game Theory
6. Visible Light Communication
7. Audio Communication
9. Mobile Computing for Automated Medicine Delivery

**Lecture notes**

- The course material will be made available by the lecturer.
- The Java 802 protocol emulator “JEmula802” from https://bitbucket.org/field/jemula802

**Prerequisites / notice**

- Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required).
Abstract
Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.

Objective
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include:

- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security

Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.
Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensible to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
Physically-Based Simulation in Computer Graphics

Abstract
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Objective
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Content
The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

Prerequisites / notice
Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

Security of Wireless Networks

Abstract
This course discusses physical layer aspects of wireless communication and a wide range of security-related topics in the domain of wireless technologies. It mainly targets computer science students. Though useful, a background in signal processing or physical layer concepts is not required. A basic understanding of security (e.g. as taught in 252-0211.00L Information Security) is recommended.

Objective
After this course, students should be able to describe and classify security goals of and attacks on various wireless networks and technologies, with an emphasis on physical layer aspects.

Content
- Introduction to wireless communication
- Physical layer security schemes
- Spreading techniques and their application in jamming-resilient communication and Global Navigation Satellite Systems (GNSSs)
- Secure ranging with Ultra-Wide Band (UWB)
- Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Social Competencies
- Cooperation and Teamwork fostered

Personal Competencies
- Critical Thinking fostered

System Security

Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making fostered
- Problem-solving fostered

Social Competencies
- Communication fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered

Geometry: Combinatorics and Algorithms

Abstract
Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

Objective
The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains.

In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

Content
Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in H^d, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chans Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Lecture notes
yes

Literature

Prerequisites / notice
Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.
Abstract

This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective

The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content

This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature

Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

227-2210-00L Computer Architecture W 8 credits 6G+1A S. Sadrosadati, O. Mutlu

Abstract

Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective

We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicores processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content

The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

Lecture notes

All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

The video recordings of the lectures are expected to be made available after lectures.

See https://safari.ethz.ch/architecture for past examples.

Literature

We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

See https://safari.ethz.ch/architecture for past examples.

Prerequisites / notice


Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Problem-solving assessed

Social Competencies

Communication assessed
Leadership and Responsibility assessed

Personal Competencies

Adaptability and Flexibility assessed
Critical Thinking assessed
Self-direction and Self-management assessed

263-2400-00L Reliable and Trustworthy Artificial Intelligence W 6 credits 2V+2U+1A M. Vechev

Abstract

Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Objective

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.
The course is split into 4 parts:

**Analytical Competencies**

- We discuss all previous topics, as well as past programmability, in the context of latest foundation models (e.g., LLMs).


**Prerequisites / notice**

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

**Competencies**

- Adversarial attacks and defenses on deep learning models.
- Certified training of deep neural networks (combining symbolic and continuous methods).

**Privacy of Machine Learning**

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across vision, natural language and tabular data).
- Differential privacy for defending machine learning.
- AI Regulations and checking model compliance.

**Fairness of Machine Learning**

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness (for both vision and tabular data).
- Enforcing group fairness (e.g., demographic parity, equalized odds).

**Robustness, Privacy and Fairness of Foundation Models**

- We discuss all previous topics, as well as past programmability, in the context of latest foundation models (e.g., LLMs).

263-2520-00L  **Formal Foundations of Programming Languages**  W  7 credits  2V+1U+2P+1A  R. Jung

**Abstract**

The course covers topics in the theory of programming languages, types, and program verification, and how to construct and validate that theory with machine-checked proofs in the Coq proof assistant.

**Objective**

Students will learn how to develop machine-checked proofs, how to rigorously define the semantics of a programming language and its type system, and how to analyze and formally establish the guarantees of well-typed programs.

**Content**

The course will proceed in two parallel tracks:

- The theory track (2V) will introduce operational semantics, type systems, and type soundness proofs, starting with the simply-typed lambda calculus and then continuing with increasingly expressive languages.
- The Coq track (2G) will begin with an introduction to machine-checked proofs and the Coq proof assistant. Afterwards we will mechanize the theory developed in the first track. This is the hands-on part of the course; students will carry out these proofs in Coq themselves with instructions from the lecturer.

263-2800-00L  **Design of Parallel and High-Performance Computing**  W  9 credits  2V+2U+4A  T. Hoefler

**Abstract**

Advanced topics in parallel and high-performance computing.

**Objective**

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

**Content**

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites / notice**

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3010-00L  **Big Data**  W  10 credits  3V+2U+4A  G. Fourny
Abstract
The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

Content
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?*, +*)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Prerequisites / notice
The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Literature
Papers from scientific conferences and journals. References will be given as part of the course material during the semester.
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to foster deep learning. The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective.

263-3210-00L Deep Learning
W 8 credits 3V+2U+2A T. Hofmann

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations. In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit. The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning https://las.inf.ethz.ch/teaching/pai-f18

263-3845-00L Data Management Systems
W 8 credits 3V+1U+3A G. Alonso

Abstract
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud. The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Prerequisites / notice
The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL. The course will place an special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

263-4500-00L Advanced Algorithms
W 9 credits 3V+2U+3A J. Lengler, B. Häupler, M. Probst

Abstract
This is a graduate-level course on algorithm design (and analysis). It covers a range of topics and techniques in approximation algorithms, sketching and streaming algorithms, and online algorithms. This course familiarizes the students with some of the main tools and techniques in modern subareas of algorithm design.

Prerequisites / notice
Sufficient comfort with both (A) Algorithm Design & Analysis and (B) Probability & Concentrations. E.g., having passed the course Algorithms, Probability, and Computing (APC) is recommended, though not required formally. If you are not sure whether you’re ready for this class or not, please consult the instructor.
Artificial Intelligence in Education

- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and they can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

The course will cover topics spanning four broad themes with a focus on the first two themes:
1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: fostered
  - Decision-making: fostered
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: assessed

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed

Privacy Enhancing Technologies

Abstract
Privacy is a fundamental human right! And yet, technological advances (in particular in computer science) can often undermine privacy. In this class we will see how to formalize various notions of privacy and how to build systems that preserve privacy, by combining techniques from cryptography and statistics.

The later parts of the course will focus on applications to machine learning.

Objective
By the end of the course, students will be able to:
- Reason about privacy concerns and the appropriate formalizations
- Combine tools from cryptography and statistics to build privacy mechanisms
- Assess, evaluate and prove privacy protection of a mechanism

Content
The first half of the class will cover topics from cryptography such as secure multiparty computation, zero-knowledge proofs, PIR, ORAM, anonymous communication, etc.

The second half will cover statistical notions of privacy, in particular differential privacy, and selected topics in machine learning privacy.

Lecture notes
Lecture notes will be posted on Moodle.

Literature
Boneh & Shoup - A Graduate Course in Applied Cryptography

Prerequisites / notice
Basic knowledge in cryptography, probability and machine learning is recommended but not required.

Artificial Intelligence in Education

Abstract
Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.

Objective
The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.

Content
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).
Graphs are an incredibly versatile abstraction to represent arbitrary structures such as molecules, relational knowledge or social and traffic networks. This course provides a practical overview of deep (representation) learning on graphs and their applications.

Applications of Deep Learning on Graphs

This course provides theoretical and practical insights into technology entrepreneurship. It focuses on the process of building new ventures from the idea to successfully scaling its business operations.

Prerequisites
- The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.
- Solid basic knowledge in statistics, algorithms and programming.

Content
- Profiling (Problem-Solution-Fit): Here, students will learn to answer questions such as (1) what is your motivation to start a business? (2) What is the real customer problem? (2) What solution can be identified? (3) Who are the customers? (4) What is the job they need done? etc.
- Prototyping (Product-Market-Fit): After this section, students will be able to answer questions such as (1) What is the product or service that solves a customer need? (2) What is the value proposition? (3) What is the unique selling proposition? (4) What is the go-to market strategy? (5) Who are the competitors? etc.
- Sourcing (Execution-Fit): Here, students will learn to address questions such as (1) What are the important team roles? (2) How do we build the right network and partners? (3) What are the requirements to execute the business? (4) Are there any IP-related challenges? (5) How may we co-create with others? etc.
- Scaling (Performance-Fit): In this section, students will reflect their concept in terms of scalability. They will learn to answer questions such as (1) How do we create purpose-driven culture for growth? (2) How do we scale-up revenues? (3) How do we optimize our startup's valuation in Series-X funding? (4) What kind of exit options are there?

As a result, students develop internationally scalable and technology-driven businesses in teams. The special focus lies on the ability to successfully pitch these ventures to business angels or venture capital investors.

Literature
- Course slides and case-based literature provided by the instructor.
- Additional material pointed out by the instructor prior to and during the course.

Probabilistic Artificial Intelligence

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Prerequisites
- Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.
**Machine Learning for Genomics**

**W. Boeva**

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. The concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

**Objective**

1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

**Content**

- Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

**Prerequisites / notice**

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

**Mixed Reality**

**S. Tang**

The goal of this course is to provide students with a good understanding of mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

**Objective**

- Be able to critically analyze and assess current research in this area.

**Prerequisites / notice**

- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

**Computational Biology**

**T. Vaughan, C. Magnus, T. Stadler**

The course has the aim to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics
- epidemiology
- pathogen evolution
- macroevolution of species

**Objective**

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

**Prerequisites / notice**

Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

#### Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

### Seminars

#### 252-3811-00L Case Studies from Practice Seminar

**Title:** Case Studies from Practice Seminar

**Type:** W

**ECTS:** 4 credits

**Hours:** 2S

**Lecturers:** M. Brandis

**Abstract:** Participants will learn how to analyze and solve IT problems in practice in a systematic way, present findings to decision bodies, and defend their conclusions.

**Objective:** Participants understand the different viewpoints for IT-decisions in practice, including technical and business aspects, can effectively analyze IT questions from the different viewpoints and facilitate decision making.

**Content:** Participants learn how to systematically approach an IT problem in practice. They work in groups of three to solve a case from a participating company in depth, studying provided materials, searching for additional information, analyzing all in depth, interviewing members from the company or discussing findings with them to obtain further insights, and presenting and defending their conclusion to company representatives, the lecturer, and all other participants of the seminar. Participants also learn how to challenge presentations from other teams, and obtain an overview of learnings from the cases other teams worked on.

**Lecture notes:** Methodologies to analyze the cases and create final presentations. Short overview of each case.

**Prerequisites / notice:** Successful completion of Lecture "Information Technology in Practice".

#### 252-4601-00L Current Topics in Information Security

**Title:** Current Topics in Information Security

**Type:** W

**ECTS:** 2 credits

**Hours:** 2S

**Lecturers:** S. Capkun, K. Paterson, S. Shinde

**Abstract:** The seminar covers various topics in information security: security protocols (models, specification & verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, In management for sensor networks.

**Objective:** The main goals of the seminar are the independent study of scientific literature and assessment of its contributions as well as learning and practicing presentation techniques.

**Lecture notes:** Lecture slides will be available on moodle.

**Prerequisites / notice:** Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

**Competencies**
- Concepts and Theories: fostered
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: assessed
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Negotiation: assessed
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed
The seminar covers various topics in information security, including network security, cryptography and security protocols. The participants are expected to read a scientific paper and present it in a 35-40 min talk. At the beginning of the semester a short introduction to presentation techniques will be given.

Selected Topics
- security protocols: models, specification & verification
- trust management, access control and non-interference
- side-channel attacks
- identity-based cryptography
- host-based attack detection
- anomaly detection in backbone networks
- key-management for sensor networks

Literature
The reading list will be posted on the course web site.

252-5051-00L Advanced Topics in Machine Learning  
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
In this seminar, recent papers of the pattern recognition and machine learning literature are presented and discussed. Possible topics cover statistical models in computer vision, graphical models and machine learning.

Objective
The seminar “Advanced Topics in Machine Learning” familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper. An important goal of the seminar presentation is to summarize the essential ideas of the paper in sufficient depth while omitting details which are not essential for the understanding of the work. The presentation style will play an important role and should reach the level of professional scientific presentations.

Content
The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

Literature
The papers will be presented in the first session of the seminar.

252-5701-00L Seminar in Advanced Topics in Vision  
The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar covers advanced topics in computer vision, such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics. Each time the course is offered, a collection of research papers is selected and each student presents one paper to the class and leads a discussion about the paper and related topics.

Objective
The goal is to get an in-depth understanding of actual problems and research topics in the field of computer vision as well as improve presentations and critical analysis skills.

Content
This seminar covers advanced topics in computer vision by reading and presenting classic and state-of-the-art papers. Each time the course is offered, a collection of research papers are selected covering topics such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction and others. Each student presents one paper to the class and leads a discussion about the paper and related topics. All students read the papers and participate in the discussion.

Lecture notes
no script

Literature
Individual research papers are selected each term.

263-2100-00L Research Topics in Software Engineering  
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar is an opportunity to become familiar with current research in software engineering and more generally with the methods and challenges of scientific research.

Objective
Each student will be asked to study some papers from the recent software engineering literature and review them. This is an exercise in critical review and analysis. Active participation is required (a presentation of a paper as well as participation in discussions).

Content
The aim of this seminar is to introduce students to recent research results in the area of programming languages and software engineering. To accomplish that, students will study and present research papers in the area as well as participate in paper discussions. The papers will span topics in both theory and practice, including papers on program verification, program analysis, testing, programming language design, and development tools. A particular focus will be on domain-specific languages.

Literature
The publications to be presented will be announced on the seminar home page at least one week before the first session.

Prerequisites / notice
Organizational note: the seminar will meet only when there is a scheduled presentation. Please consult the seminar's home page for information.

263-3504-00L Hardware Acceleration for Data Processing  
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Objective
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Content
The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

Prerequisites / notice
Students taking this seminar should have the necessary background in systems and low level programming.

263-3713-00L Advanced Topics in Human-Centric Computer Vision  
The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar covers advanced topics in computer vision by reading and presenting classic and state-of-the-art papers. Each time the course is offered, a collection of research papers are selected covering topics such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction and others. Each student presents one paper to the class and leads a discussion about the paper and related topics. All students read the papers and participate in the discussion.

Objective
The goal is to get an in-depth understanding of actual problems and research topics in the field of computer vision as well as improve presentations and critical analysis skills.

Content
This seminar covers advanced topics in computer vision by reading and presenting classic and state-of-the-art papers. Each time the course is offered, a collection of research papers are selected covering topics such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction and others. Each student presents one paper to the class and leads a discussion about the paper and related topics. All students read the papers and participate in the discussion.

Lecture notes
no script

Literature
Individual research papers are selected each term.

263-2100-00L Research Topics in Software Engineering  
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar is an opportunity to become familiar with current research in software engineering and more generally with the methods and challenges of scientific research.

Objective
Each student will be asked to study some papers from the recent software engineering literature and review them. This is an exercise in critical review and analysis. Active participation is required (a presentation of a paper as well as participation in discussions).

Content
The aim of this seminar is to introduce students to recent research results in the area of programming languages and software engineering. To accomplish that, students will study and present research papers in the area as well as participate in paper discussions. The papers will span topics in both theory and practice, including papers on program verification, program analysis, testing, programming language design, and development tools. A particular focus will be on domain-specific languages.

Literature
The publications to be presented will be announced on the seminar home page at least one week before the first session.

Prerequisites / notice
Organizational note: the seminar will meet only when there is a scheduled presentation. Please consult the seminar's home page for information.

263-3504-00L Hardware Acceleration for Data Processing  
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Objective
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Content
The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

Prerequisites / notice
Students taking this seminar should have the necessary background in systems and low level programming.
The learning objective is to analyze selected research papers published at top computer vision and machine learning venues. A key focus will be on identifying and discussing open problems and novel solutions in this space. The seminar will achieve this via several components: reading papers, technical presentations, writing analysis and critique summaries, class discussions, and exploration of potential research topics.

The goal of the seminar is not only to familiarize students with exciting new research topics, but also to teach basic scientific writing and oral presentation skills. The seminar will have a different structure from regular seminars to encourage more discussion and a deeper learning experience.

We will treat papers as case studies and discuss them in-depth in the seminar. Once per semester, every student will have to take one of the following roles:

Presenter: Give a presentation about the paper that you read in depth.

Reviewer: Perform a critical review of the paper.

Prerequisites / notice
All other students: read the paper and submit questions they have about the paper before the presentation. Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.

Competencies
Method-specific Competencies
Analytical Competencies
Social Competencies
Communication
Personal Competencies
Critical Thinking

263-4902-00L Seminar on User-Centered Programming Interfaces
The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This course introduces students to research topics around the principles and practices of designing user-centered programming interfaces. We will explore and discuss research topics on understanding programmers from specialized domains, interactive programming paradigms, collaborative interfaces, learning-oriented interfaces, and AI's impact on future programming interfaces.

Objective
The goal of this course is for students to gain a comprehensive understanding of state-of-the-art HCI research on user-centered programming interfaces. Additionally, students will develop skills in reading, presenting, summarizing, and critiquing research papers.

Content
This is a research seminar course where we meet weekly for two-hour discussions on selected papers. Students are expected to lead a presentation on the assigned topic and actively participate in the discussions.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Leadership and Responsibility
Self-presentation and Social Influence

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

263-5100-00L Topics in Medical Machine Learning
The deadline for deregistering expires at the end of the fourth week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar discusses recent relevant contributions to the fields of medical machine learning and related areas. Each participant will hold a presentation and lead the subsequent discussion.

Objective
Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize it for presentation to an audience. The necessary skills to successfully present the key points of existing research work are the same as those needed to communicate own research ideas. In addition to holding a presentation, each student will both contribute to as well as lead a discussion section on the topics presented in the class.

Content
The topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.

Prerequisites / notice
Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

263-5702-00L Seminar on Digital Humans
The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar covers advanced topics in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

Objective
The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills.
This seminar covers advanced topics in digital humans including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All students read the papers and participate in the discussion.

Individual research papers are selected each term. See https://vlg.inf.ethz.ch/, https://igl.ethz.ch/, and http://graphics.ethz.ch/ for example papers.

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<th>Competencies</th>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
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CAS in Computer Science - Key for Type

<table>
<thead>
<tr>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
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<tbody>
<tr>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

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<tr>
<th>lecture</th>
<th>practical/laboratory course</th>
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<tr>
<td>lecture with exercise</td>
<td>independent project</td>
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<td>exercise</td>
<td>diploma thesis</td>
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<tr>
<td>seminar</td>
<td>revision course / private study</td>
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<td>colloquium</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Machine Learning in Finance and Insurance

- Compulsory Modules
- Elective Modules
- Project Work

### Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>ECTS</th>
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<td>V</td>
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<td>G</td>
<td>lecture with exercise</td>
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ECTS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The "CAS in Future Transport Systems: New Business Models" takes place every 1.5 years according to the program website.

Course duration: Six months part time


### Major Courses

This module addresses the demand for new business models for future transport systems. Why and in what way do people wish to be mobile? What are the economic, social and legal framework conditions, and how will these develop? What approaches leading to new value propositions will follow?

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>166-0300-00L</td>
<td>Framework Conditions and Transport Behaviour</td>
<td>O</td>
<td>3.5 credits</td>
<td>3G</td>
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</tbody>
</table>

**Abstract**

This module addresses the demand for new business models for future transport systems. Why and in what way do people wish to be mobile? What are the economic, social and legal framework conditions, and how will these develop? What approaches leading to new value propositions will follow?

**Objective**

- Participants can tell the difference between drivers of mobility which cannot really change and those which can change;
- are able to identify the effects of path dependence on transport systems and future transport systems;
- are familiar with the socio-psychological factors involved in transport vehicle acquisition and transport behaviour, and can apply them in ideas for new business models;
- are able to judge the significance of travel time, driving time and fixed costs and use this knowledge to identify new business models;
- are able to design incentives which will trigger maximum changes in behaviour and/or facilitate cooperative behaviour;
- are able to embed electric mobility conceptually such that its potential is realised and the associated risks are minimised;
- are familiar with the framework conditions and efficient drivers required to replace overland transport with air transport;
- are able to assemble combinations of political and market instruments on the basis of their efficiency profiles and side-effects in order to realise efficiency potentials and changes in behaviour;
- are able to design policy and market measures in such a way that they minimise rebound effects (including those in connection with automatic and fully autonomous vehicles);
- are able to recognise the properties of automatic and fully autonomous vehicles which are particularly suitable for new business models.

**Content**

- Why are people mobile? What resources (time, money, space) do they invest in mobility?
- What are the various qualities of transport services (comfort/stress, risk/safety, plannability, multifunctionality)?
- What are the various resource and quality profiles of current transport services, and what mutual dependencies are there?
- What current mobility demands are unsated? Why are they unsated? What future key technologies might change this?
- What current forms of mobility might be substituted by other transport services? If they were substituted, how would the necessary resources and transport service qualities change?

**Methods**

- Group work (groups of four and groups of two)
- Creative methods for generating value propositions
- Tasks in preparation for the fourth course day: design, implementation and analysis of a small survey of potential target clients regarding a not-yet-existing business model

**Case studies**

- Reciprocal presentation of personally compiled case studies

**Lecture notes**

- Distributed at start of module.

**Literature**

- Distributed at start of module.

**Prerequisites / notice**

Announced to students of the of the MAS | CAS at the beginning of the term.

---

This module addresses the implementation of (digital) strategies and innovative business models of the future and elucidates the drivers, inhibitors and challenges of business model innovation. Using suitable methods and procedures, participants in the module develop, evaluate and refine prototypes of sustainable future business models.

**Objective**

- Participants are able to understand and explain the core issues, concepts and strategies of business model innovation;
- are able to describe the relevance and the process of business model development;
- are able to translate a personally developed business case into a sustainable business model;
- are able to apply suitable design strategies to optimise a personally developed business model;
- are able to appropriately embed new business models into a corporate or business segment strategy;
- are able to assess the strengths, weaknesses, opportunities and risks of a business model;
- are able to convincingly present their own business case / business model in a structured manner to relevant stakeholder groups (investors, board members, clients, partners);
- are able to engage with and develop various points of view to assess business models;
- are able to shape a modelling process for themselves and reflect on it.
Business model innovation:
- Conceptual foundations of business model innovation
- Drivers, inhibitors and challenges of business model innovation
- Business model innovation in established organisations and structures
- Case study and mini cases in the context of transport system / mobility business model innovation

Business modelling (essentials):
- Business model thinking and modelling
- The Business Model Canvas as a conceptual and methodological tool
  - Customer benefits / value propositions
  - Demand side
  - Supply side
- Business model patterns

Business modelling (application)
- Creation of a real business case for business modelling
- Business model prototyping (basis: Business Model Canvas)
- Evaluation and review/re-prototyping of participants’ own business cases / business models

Incorporating new business models into corporate / business segment strategies
- Fit with strategic analysis
- Compliance with corporate or business segment strategy
- Contribution to strategy implementation

Presenting business models convincingly (basics/application)
- Basics of business model presentation
- Development of participants’ own storylines and presentation structure (business value concept)
- Pitching of own business case / business model

Methods
- Blended learning elements to prepare for classroom sessions
- Case studies and examples; group work (4-person and 2-person groups)
- Classroom discussions to introduce relevant concepts and instruments
- Homework for the 4th and 5th NG-2 course days: Develop a structured presentation of a personally developed business case (business model) for delivery to relevant stakeholder groups (investors, board members, clients, partners)

Incorporating new business models into corporate / business segment strategies
- Fit with strategic analysis
- Compliance with corporate or business segment strategy
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Presenting business models convincingly (basics/application)
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- Development of participants’ own storylines and presentation structure (business value concept)
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Methods
- Blended learning elements to prepare for classroom sessions
- Case studies and examples; group work (4-person and 2-person groups)
- Classroom discussions to introduce relevant concepts and instruments
- Homework for the 4th and 5th NG-2 course days: Develop a structured presentation of a personally developed business case (business model) for delivery to relevant stakeholder groups (investors, board members, clients, partners)
Abstract

For companies it is essential to realise products quickly, economically and in a customer-oriented way. In this context approaches to agile and user-centred product development such as Scrum and Design Thinking are increasing in importance. Compared to traditional product development methods, agile methods promise higher quality and customer satisfaction coupled with reduced expenditure.

Objective

Design and realisation of product development projects for future transport systems: Participants are familiar with the methods and procedures of agile and user-centred product development and are able to apply them profitably in their enterprises.

Content

Participants define an innovation theme themselves in groups, and a selection of topics is then drawn from this theme for module group work. The module takes participants through the whole process, from the analysis of target groups and their requirements through project conception and planning to implementation in example form. The course is practical and uses concrete examples. At the end of the module participants will have deployed the methods of agile and user-centred product development to work very practically through a theme they have developed themselves, and will have become familiar with the typical application scenarios, advantages and hurdles associated with these methods.

Lecture notes

Distributed at start of module

Literature

Distributed at start of module

Prerequisites / notice

Announced to students of the MAS/CAS at the beginning of the term

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>166-0303-00L</td>
<td>Agile and User-Centered Innovation</td>
<td>O</td>
<td>2.5</td>
<td>2G</td>
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*Does not take place this semester.*
### Key for Hours

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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Future Transport Systems: Systemic Aspects

The "CAS in Future Transport Systems: Systemic Aspects" takes place every 1.5 years according to the program website.

Course duration: Six months part time


Major Courses

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<tr>
<th>Number</th>
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<tr>
<td>166-0100-00L</td>
<td>Transport Systems: Dynamics and Future Developments</td>
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<td></td>
<td>Does not take place this semester.</td>
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<td>3 credits</td>
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<td></td>
<td>Interrelationships and dynamic change and the impact of these on mobility and transportation are being investigated in this module. The module addresses desirable future development of urban transport systems in Switzerland by covering and critically examining authentic, existing transport scenarios (e.g. ARE) in an exercise setting which deploys backcasting.</td>
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<td>- understand the complexity of the transport system status quo as a whole, and are able to describe it qualitatively and create an operational and/or working context (K1).</td>
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<td>- understand the development of transport systems and future transport scenarios over time, and can infer objectives from the latter (K2).</td>
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<td>- understand the dynamics between spatial quality and mobility behavior and can evaluate how measures to promote active mobility can contribute to a more sustainable transport system (K3).</td>
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<td>- understand how digitalisation drives new mobility services (mobility as a service), and are able to qualitatively estimate the changes these bring to transport systems as a whole (K4).</td>
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<td>- are able to pinpoint the challenges and potential of the transition to autonomous transport forms (K5).</td>
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<td>Deepen understanding of complex transport systems and their dynamics past – status quo – future</td>
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<td>- Consolidate a foundation in the dynamics of transport systems: elements and their interrelationships</td>
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<td>- Overview and selection of methods/approaches for the development and analysis of scenarios</td>
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<td>- Future perspectives (ARE), target scenarios</td>
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<td>- Transformation and change in systems</td>
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<td>- Transport policy and the potential of regulation</td>
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<td>- Excursion: &quot;Infrastructure to support active mobility: Bike capital Bern&quot;</td>
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<td>Methods selected</td>
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<td></td>
<td>- System analysis, scenario analysis, foresight, indicators for sustainable mobility, Case studies, reading and discussion of thesis papers and scientific publications</td>
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<td>Lecture notes</td>
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</table>

| 166-0101-00L | Development and Assessment of Transport Scenarios  |
|              | Does not take place this semester.                       |
|              | This module familiarises participants with current methods of developing and evaluating transport scenarios. These include analysis of the interrelationship of space and traffic; traffic modelling methods; and evaluation according to economic and planning criteria. |
|              | Participants                                                        |
|              | - are familiar with suitable methods for developing transport scenarios and how to analyse and evaluate them. In particular, they know how to address the challenges of evaluating future forms of transport; |
|              | - are able to select a suitable method and determine an evaluation concept with relation to a specific problem. |
|              | Content                                                             |
|              | - Methodological foundations of traffic modelling (44-level model, activity-based model, agent-based simulation) |
|              | - Design and evaluation of transport scenarios using MATSim (traffic simulation) with a focus on transport with autonomous vehicles |
|              | - Interrelationship of space and traffic (accessibility measurement, settlement density and mixed usage) and what to consider in designing and evaluating transport scenarios |
|              | - Approaches to evaluation of traffic scenarios (cost-benefit analyses and their foundations, methodological limits), analysis of effects taking into account user group and space type |
|              | - Ecobalancing with Life Cycle Assessment (LCA) in addressing passenger and goods transport issues |
|              | - Development of case studies on shared transport and mobility with an activity- and agent-based transport simulation model |
|              | Methods selected                                                    |
|              | - Aggregated and activity-based transport demand models |
|              | - Agent-based simulation                                             |
|              | - Cost-benefit analysis                                              |
|              | - Accessibility analysis                                             |
|              | Case studies                                                        |
|              | - Shared mobility                                                    |
|              | - Autonomous mobility                                                |
|              | - Densified settlement development and slow forms of mobility         |
|              | Lecture notes                                                      |
|              | Distributed at start of module                                      |
|              | Literature                                                         |
|              | Distributed at start of module                                      |
|              | Prerequisites / notice                                              |
|              | Announced to students of the of the MAS / CAS at the beginning of the term |

| 166-0102-00L | Foundations for the Design of Transport System  |
|              | Innovation and Change Processes                                      |
|              | Does not take place this semester.                                    |
|              | Objective                                                            |
|              | Participants are able...                                              |
|              | - to understand the economic and social-science fundamentals of innovation and change processes in the area of transportation; |
|              | - to analyse the foundations, opportunities and challenges of disruption in mobility systems; |
|              | - to set this concepts and frameworks in context to pathways towards more sustainable mobility; |
|              | - and to set these concepts and frameworks constructively in context to their own work practice. |

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 490 of 2667
In this module, innovation, change and transitions in transportation systems on different levels are discussed from different complementary perspectives. Both economic and social science approaches to the analysis, anticipation and governance of innovation processes are presented, discussed and applied to current issues. Topics are:
- Respective theories and methods;
- Innovation as an economic discovery process, measuring innovation;
- Emerging trends as new opportunities for innovation;
- Innovation today in the transportation/mobility system: theoretical basis and concrete examples;
- Transition of socio-technical systems, co-evolution of technical and societal dynamics;
- The relevance of social acceptance and ethical aspects for innovations in mobility.

### Lecture notes
Distributed at start of module

### Literature
Distributed at start of module

### Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

#### CAS Thesis

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>166-0190-00L</td>
<td>CAS Thesis on System Aspects ■</td>
<td>O</td>
<td>3</td>
<td>5D</td>
<td>C. Onder, to be announced</td>
</tr>
</tbody>
</table>

### CAS in Future Transport Systems: Systemic Aspects - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
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<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The module provides a solid introduction to integrated technology assessment with regard to economic, ecological and social criteria. It introduces life cycle assessment (LCA), cost assessment, risk assessment and multi-criteria decision analysis. It also presents scenario analyses based upon energy-economic models which explicitly represent transport and energy-supply technologies.

### CAS in Future Transport Systems: Technology Potential

The "CAS in Future Transport Systems: Technology Potential" takes place every 1.5 years according to the program website.

**Course duration:** Six months part time


### Major Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>166-0200-00L</td>
<td>Technology Potential: Powertrain, Systems and Energy Carriers</td>
<td>O</td>
<td>3.5 credits</td>
<td>3G</td>
<td>C. Onder</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The module provides a foundation in the current situation and short- and middle-term development directions of powertrain and automotive engineering in the context of passenger &amp; goods transport. Corresponding energy sources and resulting consequences for the energy system are addressed. Participants will be enabled to identify potentials of these technologies and apply them to concrete problems.</td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Familiarity with conventional and alternative powertrain and automotive systems for future sustainable mobility, and the ability to identify and deploy their potential to address concrete problems.</td>
<td></td>
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</tr>
</tbody>
</table>
| **Content** | - Drive component efficiency rates and core fields  
- Drive and non-drive energy flow / Vehicle "driving resistance"  
- Energy chains (operating power only) and CO2 emissions to primary energy |
| **Lecture notes** | Distributed at start of module |
| **Literature** | Distributed at start of module |
| **Prerequisites / notice** | Announced to students of the of the MAS / CAS at the beginning of the term |
| 166-0201-00L | Potential of Spatial Information- and Communication Technologies | O | 3 credits | 3G | M. Raubal |
| **Abstract** | The digital revolution, spatial information and communication systems in particular, have a significant influence on the development of new transport systems. Participants acquire an in-depth understanding of the functionality and application potential of spatial information systems and services and of communication technologies for deployment in future transport systems and applications. |
| **Objective** | Familiarity with information and communication technologies (ICT) and spatial information technologies, and the ability to identify and utilise their potential to address concrete problems. |
| **Content** | - Functionality and application of geographic information systems (GIS) to represent and analyse transport systems (acquire, model, analyse and visualise geodata)  
- Deployment potentials of GIS and ICT for efficient transport solutions (tangible, non-tangible)  
- Functionality and application of mobile spatial information technologies in future transport systems  
- Methods of spatiotemporal analysis and geodata analysis  
- Technical aspects of information and communication technologies (ICT)  
- Modelling, simulation and assessment of traffic behaviour  
- Basics of autonomous driving  
- Legal aspects of geodata  
- Applications: Traffic behaviour in Switzerland; location based services for energy-efficient behaviour; GIS for the Zurich traffic system (multimodal) |
| **Lecture notes** | Distributed at start of module |
| **Literature** | Distributed at start of module |
| **Prerequisites / notice** | Announced to students of the of the MAS / CAS at the beginning of the term |
| 166-0202-00L | Integrated Assessment of Technologies and Transport Systems | O | 2 credits | 1G | |
| **Abstract** | The module provides a solid introduction to integrated technology assessment with regard to economic, ecological and social criteria. It introduces life cycle assessment (LCA), cost assessment, risk assessment and multi-criteria decision analysis. It also presents scenario analyses based upon energy-economic models which explicitly represent transport and energy-supply technologies. |
| **Objective** | An overview of suitable methods for analysing and evaluating technical systems (transport systems) and the ability to choose among them to address concrete problems. |
| **Content** | (1) Introduction to and overview of integrated assessment  
- Current status of transport in Switzerland and internationally  
- Scope and goals of integrated assessment  
- Sustainability: concept and practical implementation via criteria and indicators  
- Overview of concepts and implementation methods  

(2) Selected methods for assessing transport technologies and their application to current and future options  
- Ecobalance / life cycle assessment (LCA)  
- Location-specific assessment of health hazards and environmental pollution  
- Risk analysis  
- Internal cost assessment  
- External cost assessment  

(3) Integrated assessment of transport technologies  
- Overall costs (internal and external)  
- Multi-criteria analysis  

(4) Analysis of transport scenarios  
- Scenarios, influencing factors, policy and sustainability  
- Approaches to scenario modelling  
- Global mobility scenarios: examples  
- Transport scenarios for Switzerland using energy system models |
| **Lecture notes** | Distributed at start of module |
| **Literature** | Distributed at start of module |
| **Prerequisites / notice** | Announced to students of the of the MAS / CAS at the beginning of the term |
Energy Carrier for the Mobility of the Future

Abstract
The module includes the supply of the road mobility of the future with renewable energy. The generation, transport, processing, transfer of energy to the vehicles (refueling, charging) and the energetic evaluation are presented. Electricity, hydrogen, biogenic and synthetic fuels are considered.

Objective
The aim of the module is a detailed energetic and technical understanding of the supply of road vehicles with renewable energy. Graduates know the primary energy production as well as the end energy processing of the different energy carrier concepts. In addition, they know the legal CO2 requirements for vehicle registration and are able to qualitatively assess the impact on the Swiss energy system.

Content
- The energy system of the future; biogenic and electric renewable primary energy
- Transfer from the energy system to mobility and influences on the overall energy system

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

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CAS Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>166-0290-00L</td>
<td>CAS Thesis on Technology Potentials</td>
<td>O</td>
<td>3 credits</td>
<td>5D</td>
<td>C. Onder</td>
</tr>
</tbody>
</table>

Abstract
Does not take place this semester.

Objective
- Deal with a specific problem from the CAS Technology Potentials subject area.
- Be able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- Communicate the results appropriately.

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

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CAS in Future Transport Systems: Technology Potential - Key for Type

| O  | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z  | Courses outside the curriculum |
| W  | Eligible for credits               | Dr | Suitable for doctorate |

Key for Hours

| V  | lecture                       | P  | practical/laboratory course |
| G  | lecture with exercise         | A  | independent project         |
| U  | exercise                      | D  | diploma thesis              |
| S  | seminar                       | R  | revision course / private study |
| K  | colloquium                    |    |                              |

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### CAS in Nutrition for Disease Prevention and Health

#### Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-6101-00L</td>
<td>Nutrition and Chronic Disease</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>F. von Meyenn, M. Andersson</td>
</tr>
</tbody>
</table>

**Abstract**
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

**Objective**
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

**Content**
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

**Lecture notes**
There is no script. Powerpoint presentations will be made available on-line to students.

**Prerequisites / notice**
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-6403-00L</td>
<td>Nutrition and Performance</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>S. Mettler</td>
</tr>
</tbody>
</table>

**Abstract**
The course introduces basic concepts of the interaction between nutrition and exercise performance.

**Objective**
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

**Content**
The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

**Lecture notes**
Lecture slides and required handouts will be available on the ETH website (moodle).

**Literature**
Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

**Prerequisites / notice**
General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

<table>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-6301-00L</td>
<td>Nutrition-Related Physiology</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>F. von Meyenn, E. Gasser</td>
</tr>
</tbody>
</table>

**Abstract**
Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand.

**Objective**
Some basic knowledge in physiology is recommended for this course, which revisits important physiological topics, emphasizing their relation to nutrition. The aim is to give the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand. For students with a background in medicine, pharmacy or biology, the course is useful as a review of previously acquired knowledge. Major topics are basic neuroanatomy and neurophysiology; general endocrinology; the physiology of taste and smell; nutrient digestion and absorption; intermediary metabolism and energy homeostasis; and some aspects of cardiovascular physiology and water balance.

**Lecture notes**
Handouts for each lecture will be uploaded to Moodle every week.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods and Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>fostered</td>
</tr>
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</table>

### CAS in Nutrition for Disease Prevention and Health - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
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### Key for Hours

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<th>Key</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
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<tr>
<td>K</td>
<td>colloquium</td>
<td>ECTS</td>
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Special students and auditors need special permission from the lecturers.

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CAS in Nutrition in Medicine

Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>395-0300-00L</td>
<td>Introduction to Nutrition</td>
<td>O</td>
<td>2</td>
<td>1G</td>
<td>F. von Meyenn</td>
</tr>
<tr>
<td>Abstract</td>
<td>This first module of the CAS Nutrition in Medicine will provide an overview of the most important concepts of nutrition. The introduction to nutrition specific physiology, will be followed by a more detailed overview of the macro- and micronutrients as well as their importance to health and disease.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students can describe the basic concepts of nutrition</td>
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<tr>
<td></td>
<td>Students can name the different macronutrients and can explain how they are metabolized</td>
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<tr>
<td></td>
<td>Students can classify vitamins and minerals and can describe the most important deficiencies</td>
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</tr>
<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>assessed</td>
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</tr>
<tr>
<td></td>
<td>Methods-specific Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Social Competencies</td>
<td>fostered</td>
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</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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</tr>
<tr>
<td>395-0301-00L</td>
<td>Digital Nutrition Monitoring</td>
<td>O</td>
<td>2</td>
<td>1G</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>This module introduces the basic concepts of classic dietary assessment and of dietary reference values. In addition, novel, digital methods for food monitoring as well as health in general will be introduced. Biomarkers for nutritional assessment will build the last part of this module.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students can apply classic dietary assessment methods and interpret generated results</td>
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<td></td>
<td>Students can describe the general concept of digital health</td>
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<tr>
<td></td>
<td>Students know how to apply methods for digital nutrition monitoring and understand their benefits and limitations</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Social Competencies</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>395-0302-00L</td>
<td>Nutrition in Metabolic Disease</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>F. von Meyenn</td>
</tr>
<tr>
<td>Abstract</td>
<td>The module Nutrition in metabolic disease will cover aspects of endocrinology and physiology in relation to nutrition, as well as specifically focus on nutritional aspects of obesity (including childhood obesity), type 2 diabetes including its therapy as well as muscle and exercise. In addition, different diet forms and their effects will be discussed.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Students understand how nutrition is closely linked to endocrinology.</td>
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<tr>
<td></td>
<td>Students can develop nutritional strategies to improve health of obese patients.</td>
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<tr>
<td></td>
<td>Students can apply nutritional concepts in the support of treatment and prevention of type 2 diabetes.</td>
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<tr>
<td></td>
<td>Students can judge different diet forms in terms of their effect health/specific health aspects.</td>
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</tr>
<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>fostered</td>
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<td>fostered</td>
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</table>

CAS in Nutrition in Medicine - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
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</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
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<tr>
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<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<td>K</td>
<td>colloquium</td>
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<td></td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Module 2: Pharma Project Management and Health Communication

**Abstract**

In this module, students learn to plan, execute, and manage pharma industry projects effectively, emphasizing clear objectives and timelines. They develop skills in team collaboration, conflict resolution, and stakeholder communication to ensure project success. Students also enhance their ability to convey ideas clearly and persuasively to diverse audiences through role-playing exercises.

**Objective**

- Project Management Basics. Students know
  - About projects, project management and the project environment
  - How to define and plan my project, how to deal with stakeholders and how to manage project risks
  - How to manage a project team, develop the project plan and launch the project
  - How to monitor and report, project close-out and project leadership
  - How to handle a budget and resource management

- Workshop. Students know about:
  - Development of a generic drug product in cross-functional project teams

**Communication:**

- Intercultural communication
- Negotiation skills
- Presentation power

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: fostered
  - Analytical Competencies: fostered
  - Decision-making: fostered
  - Media and Digital Technologies: fostered
  - Problem-solving: fostered
  - Project Management: fostered

- **Method-specific Competencies**
  - Analytical Competencies: fostered
  - Media and Digital Technologies: fostered
  - Problem-solving: fostered
  - Project Management: fostered

- **Social Competencies**
  - Communication: fostered
  - Cooperation and Teamwork: fostered
  - Customer Orientation: fostered
  - Leadership and Responsibility: fostered
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: fostered
  - Negotiation: fostered

- **Personal Competencies**
  - Adaptability and Flexibility: fostered
  - Creative Thinking: fostered
  - Critical Thinking: fostered
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

### Module 7: Clinical Development

**Abstract**

Module 7 gives an overview about the several steps that have to be followed during the process of clinical development.

**Objective**

- Preclinical bridge to clinical development
- Strategy for clinical development
- Regulatory aspects of clinical development
- Good clinical practice (GCP) and quality assurance
- First in human studies (Phase I), Proof of concept studies (Phase II), Registration studies (Phase III), Post-registration studies (Phase IV)
- Monitoring
- Organizational and financial aspects of clinical development
- Portfolio and life cycle management
- Data management and simulation of a clinical study
- Personalized medicine
### Essay

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
541-1000-00L | Essay | 0 | 1 credit | 2D | R. Furegati Hafner, R. Schibli

*Only for CAS in Pharmaceuticals.*

The enrolment is done by the CAS in Pharmaceuticals study administration.

**Abstract**
The essay is an essential part of the CAS program „Pharmaceuticals – From Research to Market“ (CAS Pharm) and serves as final performance assessment.

**Objective**
The essay documents the student’s competence development during the program as well as the transfer of acquired knowledge to professional practice/activities.

**Literature**
www.postgraduate.pharma.ethz.ch documents: essay

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### CAS in Pharmaceuticals - From Research to Market - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

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### Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium |

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**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Heritage conservation is dedicated to the preservation and protection of historical buildings. In this lecture, students will learn about the theoretical positions on historic monuments and the basics of preservation in practice. The responsible reconstruction and further development of the existing building stock requires knowledge and an understanding of the theoretical positions conservation and the basics of preservation in practice. The core course of spring semester 2024 conveys this knowledge to students with the help of selected writings and discusses them in the context of various guest lectures.

In the seminar, selected texts on architectural theory and monument preservation are read together and discussed in plenary. The focus is on selected writings from John Ruskin, Gottfried Semper and Friedrich Nietzsche to Alois Riegl and Adolf Loos to Walter Benjamin, Aleida Assmann and Peter Zumthor.

The writings on architectural theory and historic preservation discussed in the seminar provide an overview of the most important theories and concepts of historic preservation. Ruskin's narrative of architectural historicity, Semper's conception of "Bekleidung" and Nietzsche's transformation of mythology are covered, as are Riegl's notions of "Erinnerungswert" and "Gegenwartswert". Loos' writings on architecture, Benjamin's notion of aura and Aleida Assmann's memory space as well as Peter Zumthor's atmosphere. Each text is discussed in terms of textual structure, conceptual history, visual language, relationship to poetry and literature, strategies of theory, etc. Identifying the levels and intersections that link a theory with other theories characterises one of the main tasks of our seminar.

Only takes place every second autumn semester (even numbered years).

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
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<td>Scientific questions of monument conservation practice</td>
<td>O</td>
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<td>2S</td>
<td>S. M. Schlachetzki, S. Langenberg</td>
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<td>063-0911-24L</td>
<td>Future Monuments</td>
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<td>2 credits</td>
<td>2V</td>
<td>S. Langenberg</td>
</tr>
</tbody>
</table>
Reading List

Monographs and edited volumes:


Dehio, Georg, Kunsthistorische Aufsätze. München 1914


Franz, Birgit, Gerhard Vinken und Johanna Blokker (Hg.), Denkmal - Werte - Bewertung, Denkmalpflege im Spannungsfeld von Fachinstitution und bürgerschaftlichem Engagement, Holzminden 2013 (Veröffentlichung des Arbeitskreises Theorie und Lehre der Denkmalpflege e.V., Band 23).

Huse, Norbert (Hg.), Denkmalpflege: Deutsche Texte aus drei Jahrhunderten, München 1984.

ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


Petzet, Michael und Gert Mader (Hg.), Praktische Denkmalpflege, Stuttgart/ Berlin/ Köln 1993.


Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


Wohlleben, Marion und Georg Mörsch, Georg Dehio und Alois Riegl - Konservieren, nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

Fundamentals and legal texts:

Stadt Zürich Hochbaudepartement, Amt für Städtebau, Denkmalpflege und Archäologie (Hg.), Schulhäuser der Stadt Zürich. Spezialinventar Archäologie und Denkmalpflege, September 2008

Stadt Zürich Hochbaudepartement, Amt für Städtebau (Hg.), Bauten, Gärten und Anlagen 1960 bis 1980. Inventarerhänzung, August 2013


Denkmalpflegegesetzgebung in den Heimatkantonen der Kursteilnehmenden.

Die Kunstdenkmäler der Schweiz

INSA – Inventare der Heimatkantone der Teilnehmenden
### Major Courses and Cooperations

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<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>The course elaborates the legal concept of “monument” in its important distinction from the respective scientific concept. It highlights its embeddedness and effect in public building law. Furthermore, it deals with legal protection instruments and procedures.</td>
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<td><strong>Objective</strong></td>
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<td>In addition to elaborating the legal concept of monuments, the course familiarises participants with legal protection instruments and procedures. It is planned to involve the participants by means of practical examples.</td>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a &quot;monument&quot;, structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with the procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer's (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zurich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.</td>
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<th>R. Rehm</th>
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<tr>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>The course provides an overview of the theory of heritage conservation. The focus is on European history and German-language texts.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>The aim of the course is to familiarise students with the essential subject areas, the most important protagonists and lines of argumentation from antiquity to the 21st century, and to contrast the different approaches to thought and their development.</td>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>In order to get to know the formation of theory, its paths and detours, the most important terms and persons in the history of monument conservation are introduced. Based on various texts, the history of the protection of architectural monuments since antiquity is illuminated. Further focal points in the history of monument preservation were during the Enlightenment, the French Revolution and in the process of the formation of nation states. The discourse on the concept and practice of monument conservation as we understand it today was led by a number of conservators in the German-speaking world around 1900. War-related destruction and the incipient building boom in Europe led to modern debates on the theory of monuments, which are still relevant today. Dealing with monument values is not an end in itself; it can be essential for the preservation of the monument or for historical mediation. Critical positions on the tasks, goals or practices of heritage preservation can only be developed against the background of a knowledge of its historical approaches.</td>
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</table>

| Literature   |                                    |      |      |       |         |
|--------------|                                    |      |      |       |         |
|              | Leo Schmidt, Einführung in die Denkmalpflege, Darmstadt 2006. |
|              | Wolfgang Götz, Beiträge zur Vorgeschichte der Denkmalpflege. Die Entwicklung der Denkmalpflege in Deutschland vor 1800 (Diss. Leipzig 1955), Zurich 1999 (Veröffentlichungen des Instituts für Denkmalpflege an der ETH Zürich, vol. 20). |
|              | Gottfried Kiesow, Einführung in die Denkmalpflege, Darmstadt 1982. |
|              | Denkmalschutz. Texte zum Denkmalschutz und zur Denkmalpflege, Bonn 1996 (Schriftenreihe des Deutschen Nationalkomitees für Denkmalschutz, vol. 52). |
|              |                                                      |      |      |       |         |
| **Prerequisites / notice** | To follow |      |      |       |         |

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 500 of 2667
Abstract
In addition to theory, heritage conservation also plays an important practical role in the current building revolution. In order to make the diverse possibilities in architecture visible, this course develops new strategies for communicating the discipline of monument preservation for an exhibition on this topic at SAM in 2025.

Objective
The aim of the seminar is to develop concepts for communicating and exhibiting heritage-related content and debates that go beyond specialist discourse and address a broader public. As part of the course, participants will acquire in-depth knowledge of various exhibition strategies in the field of architecture and will have the opportunity to develop exhibits for an exhibition organised by the SAM Swiss Architecture Museum (Basel) in collaboration with the Chair of Construction Heritage and Monument Preservation at ETH Zurich and ICOMOS Suisse in spring 2025.

Content
At a time when the maintenance of existing buildings is seen as an essential element of the building revolution, the theory and practice of heritage conservation is taking on an integral role. Nevertheless, heritage conservation still has to contend with image problems: people often misunderstand exactly what its aim is and, unaware of its mission, principles and (still highly topical) theories, the discipline is often assumed to have a purely conservative attitude. 50 years after the European Year of Monument Conservation in 1975, when the whole of Europe was dominated by the question of how to preserve the built heritage, there is no need for a fundamental repositioning, but there is certainly a need for an “update” on issues of monument conservation and its attitude in the face of current challenges. The joint exhibition at the SAM Swiss Architecture Museum in spring 2025 is dedicated to this topic. The course offers the opportunity to deal with architectural exhibition strategies and to participate in the development of various concepts for communicating the theory and practice of heritage conservation. New guiding principles for the future practice of heritage conservation will be jointly derived on the basis of best practice examples. In group work, current examples of successful cooperation between heritage conservation and architecture will be analyzed and documented for presentation in the exhibition in the form of drawings, texts and models. Depending on the number of participants, other parts of the exhibition can also be the subject of the work.

Prerequisites / notice
The course addresses primarily students of the MAS ETH in Denkmalpflege und Konstruktionsgeschichte and the CAS ETH in Future Heritage.

Competencies

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CAS in Preservation - Key for Type

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<thead>
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</tr>
<tr>
<td>W+ Eligible for credits and recommended</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>W</td>
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<td>Dr</td>
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Key for Hours

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<td>G</td>
<td>lecture with exercise</td>
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<td>A</td>
<td>independent project</td>
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<td>U</td>
<td>exercise</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>seminar</td>
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<td>R</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### CAS in Public Governance and Administration

#### CAS Thesis

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<td>R. Perich</td>
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</table>

**Abstract**

In their CAS thesis, participants synthesize their learning and apply their insights to their own institutions or examine a relevant topic employing the course methodologies.

**Objective**

Practical application of course content and concepts.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Problem-solving: fostered

- **Personal Competencies**
  - Creative Thinking: fostered
  - Critical Thinking: assessed
  - Self-direction and Self-management: fostered

#### Module

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**Abstract**

The programme equips the next generation of leaders in the public sector and other sectors dealing with governance matters with the necessary competencies to tackle complex governance challenges.

**Objective**

Participants learn to:

- Understand key governance frameworks and international blueprints; comprehend underlying drivers & challenges affecting governance; dissect multi-dimensional policy issues; lead effectively across the spectrum of technical, human and conceptual challenges.

**Content**

- The program encompasses a sequence of one or half-day modules, which are organized into three interdisciplinary learning blocks:
  - I. Contemporary Governance
  - In this block, participants examine the broad frameworks within which public sector work takes place. Students will explore what governance in the 21st Century means as well as the theoretical and practical nature of organizational, legal, regulatory and financial dimensions of public institutions and processes. With input from multiple disciplines, students gain the ability to contextualize and critically assess the local, national as well as international context of their individual work.
  - II. Public Management
  - In this block, students are challenged to expand their management toolbox through lectures providing them with theoretical context and practical insights into various aspects of public management. The goal is for participants to enhance their ability to lead and motivate teams, to negotiate effectively and to communicate with a variety of stakeholders.
  - III. Policy Domains
  - This block covers relevant and rapidly changing policy domains. Special attention is paid to interlinkages between specific policy areas. Students gain the big picture knowledge necessary to make informed managerial decisions within complex processes and initiatives.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: fostered
  - Problem-solving: fostered

- **Social Competencies**
  - Cooperation and Teamwork: assessed
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: fostered
  - Negotiation: fostered

- **Personal Competencies**
  - Adaptability and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: fostered
  - Self-direction and Self-management: fostered

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**CAS in Public Governance and Administration - Key for Type**

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<th>Key</th>
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**Key for Hours**

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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Module I: Pharmacy and Legislation

**Abstract**

Module I:
Knowledge of the fundamentals of development, preparation, testing and stability of sterile radiopharmaceutical preparations. Acquisition of basic information on European legislation in Radiopharmacy including GMP and Pharmacopoeia.

**Objective**

- Good manufacturing practice (GMP) of classical radiopharmaceuticals
- GMP: industrial point of view
- Molecular and cellular aspects of radiobiology
- Pharmacopoeia
- Pharmacopoeia — how to use it
- Design of dosage forms for pharmaceuticals
- Pharmaceutical packaging
- Methods of preparation of sterile products
- Aseptic preparation
- The role of excipients in parenteral radiopharmaceutical preparations
- Sterility testing and endotoxin determination
- Particulate contamination
- Principles of medicinal chemistry
- An overview of modern pharmaceutical analysis
- Genetic engineering
- Stability and shelf-life of pharmaceuticals
- (in)stability of radiopharmaceuticals
- Legislation in radiopharmacy
- European directives – GMP
- Specific radiopharmaceutical legislation
- Clinical trials directive and related documents
- The small scale, non-commercial preparation of radiopharmaceuticals
- GMP of PET radiopharmaceuticals
- Quality assurance and preparation of SOP
- Water for pharmaceutical use
- Practicals: visit to hospital radiopharmacy
- Basic concepts of pharmacokinetics
- Drug regulatory affairs
- Microbiology in Pharmacy
- Visit to pharmaceutical company

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Social Competencies
  - Communication
- Personal Competencies
  - Cooperation and Teamwork

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### Module III: Radiopharmacology and Clinical Radiopharmacy

**Abstract**

Knowledge about the fundamentals of pharmacokinetics and pharmacokinetic modelling, the basic concepts of pharmacology and toxicology, radiopharmaceutical monographs in the European pharmacopoeia, radiological imaging modalities and the basics of applied statistics in biomedical research. Understanding the fundamentals of nuclear medicine: Diagnostic applications in neurology and oncology.

**Objective**

- Understanding basics of gene engineering and pharmacokinetics
- Good manufacturing practice (GMP) of classical radiopharmaceuticals
- GMP: industrial point of view
- Molecular and cellular aspects of radiobiology
- Pharmacopoeia
- Pharmacopoeia — how to use it
- Design of dosage forms for pharmaceuticals
- Pharmaceutical packaging
- Methods of preparation of sterile products
- Aseptic preparation
- The role of excipients in parenteral radiopharmaceutical preparations
- Sterility testing and endotoxin determination
- Particulate contamination
- Principles of medicinal chemistry
- An overview of modern pharmaceutical analysis
- Genetic engineering
- Stability and shelf-life of pharmaceuticals
- (in)stability of radiopharmaceuticals
- Legislation in radiopharmacy
- European directives – GMP
- Specific radiopharmaceutical legislation
- Clinical trials directive and related documents
- The small scale, non-commercial preparation of radiopharmaceuticals
- GMP of PET radiopharmaceuticals
- Quality assurance and preparation of SOP
- Water for pharmaceutical use
- Practicals: visit to hospital radiopharmacy
- Basic concepts of pharmacokinetics
- Drug regulatory affairs
- Microbiology in Pharmacy
- Visit to pharmaceutical company

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Social Competencies
  - Communication
- Personal Competencies
  - Cooperation and Teamwork

---

The enrolment is done by the CAS study administration.
### Objective

- Pharmacokinetics and kinetic-modelling
- Statistics and practical session
- Radiotracers in biochemistry and molecular pharmacology
- Selective modification of peptides and proteins to target GPCRs
- Demonstration of experimental set up: Peptide and protein modification, radioactive assays in biochemistry
- Visit ABX Radeberg
- Nuclear medicine: basics and therapy
- Immunology
- Drug interventions/interactions/adverse reactions
- Pharmacology basics, special aspects, clinical studies
- Toxicology
- Teatsystems in toxicology and targeted therapeutics and nucleic acids
- Nuclear medicine: clinical diagnostic applications in neurology
- Nuclear medicine: visit to SPECT facility and radiopharmaceutical GMP lag (Tc, Ga, therapy)
- Radiological imaging modalities- technology and applications
- Radiopharmaceutical monographs in the European pharmacopoeia
- Practical session, visit: cyclotron, GMP PET production and quality control, PET and PET/CT, therapy unit
- Radioligand-binding-assays/autoradiography
- In house tours in groups: radioligand-binding-assays, autoradiography, metabolite analytics with LC-MS, cyclotron and radiochemistry, highlights in Leipzig
- Biological effects of radiation
- Radiotracer transport and blood brain barrier
- Radiotracers for neuroimaging

### Competencies

#### Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

#### Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

#### Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### CAS in Radiopharmaceutical Chemistry, Radiopharmacy - Key for Type

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### Key for Hours

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<td>diploma thesis</td>
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<td>revision course / private study</td>
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### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Introduction

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<td>135-0001-00L</td>
<td>Introduction: Basics of Spatial Planning</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Kissling, A. Rupf, J. Van Wezemael</td>
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Abstract: Orientation and preparation for further education in the field of spatial planning and development. Introduction to the Spatial Planning Act and its instruments, assessment of participants' knowledge. Completion through mandatory assessment.

## Spatial Development and Planning Practice

<table>
<thead>
<tr>
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<td>Module 1: Spatial Planning</td>
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Abstract: Overview of current and future tasks of spatial planning, discussion of formal and informal instruments, and introduction to a methodical way of action-oriented planning. (Tasks, methods and instruments).

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Abstract: Inputs for the integrated development of livable urban spaces in connection with central aspects and mechanics of mobility, open spaces, and social spaces. (In the tension field of mobility, open space, and society).

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Abstract: Discussion of the development of large-scale and cross-border spaces. Designing and planning in multi-actor networks, spatial concepts as a basis for cooperation and coordination tasks. (Designing and developing large-scale tasks).

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Abstract: Exploration of current and future questions of planning law and discussion of the further development of planning instruments and processes. (Law, process, and instruments II).

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Abstract: Module 1-5: Introduction of the task and excursion, integrated location assessment, development of viable action options and interim critique, overall concept and in-depth study, finalization and final critique.

### CAS in Spatial Development and Planning Practice - Key for Type

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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Regenerative Materials - Hygrothermal Specialisation

Offered only in the Autumn Semester.


### Modules

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<td>136-0201-00L</td>
<td>General Knowledge on Hygrothermal Building Physics</td>
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<td>G. Habert</td>
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<td></td>
<td>Regenerative Materials can be used to build high-quality envelopes and high-comfort environments. The course represents the basics of hygrothermal building physics and the state of the art in this field. It provides an overview of the type of earth- and bio-based materials that can be used and their hygrothermal properties.</td>
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<td>- Learn the diversity of regenerative materials used for high-quality envelopes and high-comfort environments</td>
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<td>- Ensure an efficient and durable impact on participants' professional development</td>
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<td>The course presents which Regenerative Materials can be used to build high-quality envelopes and high-comfort environments. It details the basics of hygrothermal building physics: Evolution of standards and models; Strength and weaknesses of Regenerative Materials; State of the art and market evolution. It also gives an overview of the diversity of earth-based materials (plasters, blocs, monolith walls); bio-based materials with fibers (straw bales, wool and rigid panels, bulk fibers) and low-impact composites (light mixes combining mineral binder to bio-sourced materials) from resource to implementation, with a synthesis of their hygrothermal properties and their impact on comfort and energy savings.</td>
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<td>- Self-presentation and Social Influence</td>
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<td>Constructive Details &amp; Implementation of Regenerative Envelops</td>
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<td></td>
<td>The course is focused on constructive details for regenerative materials used to build high-quality envelopes and high-comfort environments. The participant are mainly learning through a hands-on workshop during which they will produce different prototypes in small groups.</td>
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<td></td>
<td>- Apply knowledge from previous course on high-quality envelopes built with regenerative materials</td>
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<td></td>
<td>- Learn how to distinguish earth- and bio-based materials based on their hygrothermal properties</td>
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<td>- Ensure an efficient and durable impact on participants' professional development</td>
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<td></td>
<td>Small groups producing different prototypes during a hands-on workshop. Each group designs and realizes a prototype to explore a specific constructive technique using Regenerative Materials and considering thermal insulation, thermal mass, moisture regulation and air tightness. Monitoring devices will be installed in each prototype. These prototypes are compared to reference prototypes built with conventional building techniques.</td>
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<td>This course offers advanced knowledge on HAM (Heat Air and Moisture) modeling. The most up-to-date simulation models will be presented and used by the participants on real-case projects during simulation workshops.</td>
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<td>- Learn how to use the most up-to-date HAM simulation models</td>
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<td>- Learn how to analyse the transient hygrothermal behaviour of an envelope</td>
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<td>- Ensure an efficient and durable impact on participants' professional development</td>
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<td>Advanced knowledge on HAM modeling is presented during simulation workshops:</td>
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<td>- Transient hygrothermal behaviour:</td>
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<td>- Presentation of relevant software by experts users or developers</td>
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<td>- Presentation of a case study by the HVAC engineers in charge of the calculation</td>
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<td>- Digital parametric iteration:</td>
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Data: 02.07.2024 12:39   Autumn Semester 2024   Page 506 of 2667
Competencies | Subject-specific Competencies | Concepts and Theories | fostered
Method-specific Competencies | Analytical Competencies | fostered
| Decision-making | fostered
| Media and Digital Technologies | fostered
| Problem-solving | fostered
Social Competencies | Self-presentation and Social Influence | fostered
| Sensitivity to Diversity | fostered
Personal Competencies | Adaptability and Flexibility | fostered
| Creative Thinking | fostered

► Project

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Abstract
Based on the content of previous courses, the participants are asked to simulate and analyze the hygrothermal behavior of a building with the same constructive technique as their prototype. In addition, they have to reproduce the monitoring conditions of their prototypes and compare measurements to simulation results. The result and discussion are presented in front of a jury.

Objective
- Apply knowledge from previous courses on a case study
- Learn how to compare measurements to simulation results
- Enhance communication skills concerning high-quality envelops built with regenerative materials

Competencies
Subject-specific Competencies | Concepts and Theories | assessed
Method-specific Competencies | Analytical Competencies | assessed
| Media and Digital Technologies | assessed
| Problem-solving | assessed
Social Competencies | Communication | assessed
Personal Competencies | Adaptability and Flexibility | assessed
| Creative Thinking | assessed
| Critical Thinking | assessed

CAS in Regenerative Materials - Hygrothermal Specialisation - Key for Type

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Key for Hours

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<tr>
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<tr>
<td>G lecture with exercise</td>
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<tr>
<td>U exercise</td>
</tr>
<tr>
<td>S seminar</td>
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<tr>
<td>K colloquium</td>
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ECTS | European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
## CAS in Regenerative Materials - Structural Specialisation

### Modules

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<tr>
<th>Number</th>
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### Key for Hours

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<td>colloquium</td>
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<td>P</td>
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<td>D</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Regenerative Systems: Beyond Systems Thinking

Further information: https://systemicdesignlabs.ethz.ch/drrs-mooc-2-beyond-systems-thinking/

Modules

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Key for Hours

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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Regenerative Systems: Sustainability to Regeneration
Offered only in the Autumn Semester (two-yearly).
Further information: https://systemicdesignlabs.ethz.ch/cassustainabilitytoregeneration/

### Modules

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**Abstract**

This learning module navigates the journey from global crises to local interventions by first emphasizing the significance of resilience in DRRS. It then explores global crises through diverse perspectives in the "Framing nested crises" submodule. The subsequent submodules focus on practical skills at the community level and the societal and individual root causes of crises.

**Objective**

The "From global crises to local interventions" module is designed to achieve several key learning objectives within the Designing Resilient Regenerative Systems (DRRS) context. Participants will gain a comprehensive understanding of resilience, appreciating its richness and diversity to maximize practical applications within DRRS. The module encourages a multiperspective analysis of global crises, exploring diverse viewpoints influenced by angles, interests, training, geographies, institutions, and worldviews.

Emphasis is placed on developing practical skills at the community level, equipping participants to enhance local resilience and response capabilities within the framework of DRRS. This includes identifying and applying skills crucial for mitigating the impact of disasters and promoting community well-being.

Furthermore, the module delves into the societal and individual root causes contributing to global crises within the paradigm of DRRS. Participants will learn from experts about strategies to understand and address these root causes, fostering effective intervention at both the societal and individual levels.

Content

Through all modules, the course integrates three domains of learning competencies—cognitive, behavioral, and social—interconnected through the individual Quests of the learners.

Centered on the pivotal concept of resilience, the module facilitates a nuanced understanding of its richness and diversity for optimal application in addressing crises. Participants are guided through a multiperspective analysis of global crises, considering various viewpoints influenced by angles, interests, training, geographies, institutions, and worldviews.

A significant focus is placed on practical skills development at the community level within the DRRS paradigm. Participants acquire the necessary tools to enhance local resilience and response capabilities, emphasizing mitigating the impact of disasters and fostering community well-being.

The module delves into the root causes of global crises at both societal and individual levels, aligning with the principles of DRRS. Experts share insights on strategies to understand and address these root causes, fostering effective interventions that resonate with the DRRS approach.

**Lecture notes**

See Module 1.1 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration

**Literature**

See Module 1.1 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration

**Prerequisites / notice**

MOOC#1 Worldviews - From Sustainability to Regeneration is a pathway to CAS#1 Sustainability to Regeneration. To be accepted into the CAS, applicants must have completed the respective MOOC by the time the CAS starts. The content from the MOOC will be supplemented in the CAS by live virtual events with experts from all over the world. In addition, after the first virtual introductory introductory week, a real design excursion to the MonViso Institute in Italy. This trip is obligatory.

The final delivery of the CAS should demonstrate the scientific base of our work in evidence-based writing with a foundation in the peer-reviewed literature and graphical, visual, systems-mapping, and spatial ways of designerly expressions. As the main deliverable, participants must submit a framed graphical Quest synthesis process map consisting of two main parts: a graphical synthesis map (pdf format) and a framing text bracket that motivates, introduces, explains, discusses, and concludes the synthesis map.

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories assessed
- Techniques and Technologies fostered

**Method-specific Competencies**

- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

**Social Competencies**

- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

**Personal Competencies**

- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management fostered

**Number**

131-0002-00L

**Module 2: Sustainability to Regeneration**

Does not take place this semester.

**Abstract**

This learning module focuses on exploring sustainability at a deep and critical level, encouraging participants to delve into the fundamental principles of sustainability, reflect on their mental models, and critically examine the Sustainable Development Goals. The module also aims to expand participants' thinking towards regeneration.
In this module, participants will explore sustainability comprehensively, delving into core learning objectives. The journey begins with a profound understanding of sustainability fundamentals, prompting reflection on personal mental models. Participants will critically scrutinize the Sustainable Development Goals (SDGs) and navigate sustainability science theories, explicitly focusing on concepts like Planetary Boundaries. The intersection of artificial intelligence (AI) and sustainability will be examined, fostering critical perspectives.

Practical knowledge takes center stage, focusing on soil regeneration and providing tangible insights into sustainable practices. Participants can engage with the content through flexible mediums, including videos, audio files, or transcripts, tailoring the learning experience to personal preferences.

The application of systems thinking is encouraged, prompting participants to analyze and summarize critical arguments and worldviews presented in the content. Participants are invited to develop their Quests further, facilitating a holistic exploration of sustainability concepts. Sharing written or graphical reflections with learning partners and the DRRS network promotes collaboration, creating a dynamic community of learners committed to advancing sustainability knowledge.

The learning content of this module is rich and multifaceted, offering a deep exploration of sustainability from various perspectives. Participants engage in a thoughtful journey that begins by understanding the fundamental principles of sustainability and reflecting on personal mental models. Critical examination of the Sustainable Development Goals (SDGs) and exploring sustainability science theories, including concepts like Planetary Boundaries, provide a robust theoretical foundation.

The module goes beyond theory to address the practical aspect of sustainability, focusing on soil regeneration. Participants can choose their preferred learning medium, videos, audio files, or transcripts, enhancing accessibility.

Including artificial intelligence (AI) in the sustainability discourse adds a contemporary dimension, prompting participants to develop critical perspectives on the evolving relationship between technology and sustainability.

Lecture notes
See Module 1.2 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration

Content
The learning content of this module is rich and multifaceted, offering a deep exploration of sustainability from various perspectives. Participants engage in a thoughtful journey that begins by understanding the fundamental principles of sustainability and reflecting on personal mental models. Critical examination of the Sustainable Development Goals (SDGs) and exploring sustainability science theories, including concepts like Planetary Boundaries, provide a robust theoretical foundation.

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Lecture notes
See Module 1.2 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration

Prerequisites / notice
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Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered
Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed
Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered
Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

Module 3: Worldviews

Does not take place this semester.

O 2 credits 1G to be announced

Abstract
This learning module titled “Worldviews” delves into the exploration of how individuals perceive the world and construct their understanding of reality. It emphasizes the significance of worldviews, defined as fundamental beliefs and modes of participation in the broader context.

Objective
In this module, participants will embark on a journey to explore the rich tapestry of worldviews, understanding how different cultures and individuals perceive and reason about the world. The learners delve into the intersection of scientific discourse and practical application (praxis), examining the profound impact of scientific perspectives on shaping our collective understanding. A key focus is introducing "warm data," a concept that adds depth to our comprehension of complex systems, demonstrated through real-world examples such as fast fashion dumps and agriforest systems.

The module highlights the role of design, emphasizing both design processes and meta-design—viewing mental maps as dynamic tools that can foster collaborative transformations toward resilient and regenerative systems. Furthermore, the participants explore the potential of artificial intelligence (AI) as a catalyst for regeneration, investigating its role in sustainable practices and contemplating ethical considerations for its responsible integration. Participants are encouraged to engage actively, broaden their perspectives, and contribute to collectively shaping a more sustainable and regenerative future through these objectives.
The module starts by delving into the fundamental concept of worldviews, emphasizing their role as foundational beliefs and modes of participation in the broader context. The inclusion of perspectives from Daniel Wahl and Jeremy Lent, as well as an exploration of indigenous and Eastern philosophies, provides a well-rounded approach to understanding diverse ways of knowing and reasoning.

Incorporating practical examples, such as fast fashion dumps in Chile and agroforestry systems in African countries, adds a tangible dimension to the theoretical discussions. This approach helps participants connect abstract concepts to real-world scenarios, fostering a deeper understanding of the implications of different worldviews on environmental and societal issues.

The emphasis on "warm data" introduces a holistic perspective, encouraging participants to consider interconnected systems and view challenges comprehensively. Including meta-design as a tool for collaborative transition promotes active engagement in shaping resilient and regenerative systems.

Furthermore, the module's exploration of the role of artificial intelligence (AI) in regeneration adds a forward-looking dimension, addressing the potential for technological innovation to contribute to sustainable practices.

The module "Reframing complexity" invites participants to explore various access points for dealing with uncertainty, fostering a holistic mindset towards complexity, offering tangible tools for navigating complex systems. The overarching objective is to enable individuals to navigate uncertainty by identifying various access points and weaving diverse perspectives into a holistic understanding of complexity.

Does not take place this semester.

Module 4: Reframing Complexity

Does not take place this semester.

Abstract

The module "Reframing complexity" invites participants to explore various access points for dealing with uncertainty, fostering a holistic perspective on complexity and encouraging a more nuanced and informed approach to navigating complex living systems.

The "Reframing complexity" module aims to empower participants to understand the intricacies of living systems deeply. Key learning goals include distinguishing between complexity and simplicity, challenging traditional views by fostering a mindset that embraces complexity, and exploring how to design resilient strategies within complex systems. The module emphasizes the role of big data and visualization tools in intervention strategies. Participants will also grasp the interconnectedness of science, praxis, data types, warm data, and AI in complex systems. The overarching objective is to enable individuals to navigate uncertainty by identifying various access points and weaving diverse perspectives into a holistic understanding of complexity.

Content

Beginning with Eric Berlow's perspective on "The Other Side of Complexity," the module challenges conventional views and introduces alternative ways of understanding intricate systems.

Fritjof Capra, a renowned figure in systems thinking, contributes to the module focusing on "Complexity Science and Systems Thinking." Participants can anticipate a deep dive into the foundations of complexity science and the principles of systems thinking.

The Hinnen Brothers bring a practical dimension to the module with "Reframe It!" where participants are guided in adopting a reframed mindset towards complexity, offering tangible tools for navigating complex systems.

Michael Stauffacher from ETH Zurich sheds light on the intersection of "Science and Praxis," providing valuable insights into how scientific knowledge translates into practical applications, particularly within the realm of complex systems.

Nora Bateson contributes to the module focusing on "Warm Data," emphasizing the significance of contextual and relational information in understanding complexity. Participants explore how such insights contribute to a more holistic understanding of complex systems.

The module further investigates the role of artificial intelligence in "When is AI Regenerative?"—examining scenarios where AI positively influences the resilience and regeneration of complex systems.

Finally, the module addresses the intricate challenges involved in "Complexities of Decarbonization," providing participants with a nuanced understanding of the hurdles and considerations in transitioning to sustainable and low-carbon practices.

Lecture notes

See Module 1.4 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration
The "Design as Nature" module unfolds through several key subchapters, each addressing crucial aspects of the relationship between humanity and the natural world. By doing so, they gain insights into creating sustainable solutions that align with the regenerative patterns observed in the natural world. Bio-infused communication emerges as a significant aspect, urging participants to explore ways of interacting with the environment inspired by nature. This approach fosters a harmonious relationship with the ecosystems we inhabit.

Finally, the module delves into the realm of nature finance, where economic mechanisms are derived from nature’s principles. The goal is to inspire a redesign of financial systems, aligning with regenerative and sustainable practices. Combining these learning goals, the "Design as Nature" module provides a comprehensive framework for reconnecting with nature, understanding its design language, and actively contributing to a more sustainable and harmonious coexistence.

Content

Beginning with a focus on biodiversity, the module underscores the vital role of diverse life forms in maintaining ecosystem health. It encourages participants to appreciate the intricate interdependence within natural environments.

"Design for Biodiversity" delves into the impact of human designs on biodiversity, urging the development of solutions that actively support and enhance the richness of life rather than compromise it.

The concept of Deep Ecology - connecting with nature is introduced to cultivate a heightened sense of connection and reverence for the environment. Participants are prompted to reflect on their relationship with nature, fostering a holistic perspective.

Moving into the realm of nature-based design, the module explores the principles of biomimicry. Participants are inspired to learn from nature’s design to create sustainable and regenerative solutions, with real-world examples highlighting the positive impact of such approaches.

Bio-infused relation building shifts the focus to communication and interaction with the environment. Participants are encouraged to build relationships with nature that are respectful and sustainable and contribute to overall ecological harmony.

Lastly, the module investigates regenerative economics, exploring economic mechanisms derived from nature. The goal is to redesign financial systems in a way that aligns with sustainable practices and contributes positively to the regeneration of ecosystems.

See Module 1.5 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration

See Module 1.5 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration
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131-0006-00L Module 6: Mind and Movement

**Does not take place this semester.**

**Abstract**
This learning module on mind and movement focuses on facilitating cultural changes by guiding participants through their own unlearning journeys. The module emphasizes the importance of enduring challenging processes to design for regeneration, build personal resilience, and lead collective co-creation.

**Objective**
The learning objectives revolve around actively cultivating a profound relationship with one's surroundings through movement, fostering a deep connection to place. The module strongly emphasizes immersive experiences, encouraging participants to fully engage and be present, providing a richer understanding of self, others, and the more-than-human world.

Self-discovery takes center stage as participants are prompted to question and challenge their perceived physical and psychological boundaries. The module equips individuals with the tools to build resilience in their engagements with place, self, and others, navigating challenges with adaptability and strength.

Exploring the transformative power of movement, participants learn to mediate their relationships with self through action, understanding, and expressing emotions physically. The curriculum also guides individuals to develop ecologically attuned and reciprocal conversations, fostering a deeper connection with human and non-human entities in their environment.

Redefining adventure becomes a key theme, encouraging participants to move beyond conventional notions and embody their practices. Participants transform routine experiences into meaningful and adventurous engagements by integrating movement and mindfulness into daily activities.

Philosophically grounded in contemporary neuroscience, the module challenges traditional views that separated the mind and body. It underscores the interconnectedness of these elements, recognizing the profound significance of movement and bodily experiences in the pursuit of self-realization and holistic growth. Through this multifaceted approach, participants are empowered to reframe their relationship with the world, themselves, and the more-than-human aspects of their environment.

**Content**
This learning module on mind and movement stands out for its holistic approach to personal and collective development. By seamlessly integrating physical movement, mindfulness practices, and ecological awareness, participants are offered a multifaceted exploration of their experiences.

A notable strength lies in the practical application of concepts, focusing on immersive experiences such as cultivating relationships through movement and redefining adventure. This hands-on approach adds a tangible and applicable dimension to the learning journey.

The module emphasizes building resilience in engagements with place, self, and others, recognizing the importance of adaptability and strength in navigating challenges. Additionally, the ecological awareness component, encouraging participants to develop attuned and reciprocal conversations with human and non-human entities, aligns with a contemporary understanding of our interconnectedness with the environment.

**Lecture notes**
See Module 1.6 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration

**Literature**
See Module 1.6 in MOOC#1 Worldviews - From Sustainability to Regeneration: https://www.edx.org/learn/ethics/eth-zurich-worldviews-from-sustainability-to-regeneration

**Prerequisites / notice**
MOOC#1 Worldviews - From Sustainability to Regeneration is a pathway to CAS#1 Sustainability to Regeneration. To be accepted into the CAS, applicants must have completed the respective MOOC by the time the CAS starts. The content from the MOOC will be supplemented in the CAS by live virtual events with experts from all over the world. In addition, after the first virtual introductory introductory week, a real design excursion to the MonViso Design excursion to the MonViso Institute in Italy. This trip is obligatory.

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### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

### CAS in Regenerative Systems: Sustainability to Regeneration - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Type</th>
</tr>
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<tbody>
<tr>
<td>O</td>
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<tr>
<td>W+</td>
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<td>W</td>
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### Key for Hours

<table>
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<tr>
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<tbody>
<tr>
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<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<tr>
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<tr>
<td>D</td>
<td>diploma thesis</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

### ECTS
- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>395-0200-00L</td>
<td>Regulatory World</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>J. Goldhahn, I. Clay, D. Schaffarczyk</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Participants will be introduced into regulations and landscape including all stake holders. The different types of medicinal products are introduced including subsequent regulations. Participants apply the knowledge in different starting scenarios.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Participants</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>-</td>
<td>understand the complexity of the regulatory landscape</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>-</td>
<td>know the main characteristics of different medicinal products and subsequent regulatory pathways</td>
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</tr>
<tr>
<td>-</td>
<td>identify the different stakeholders and players in this landscape</td>
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</tr>
<tr>
<td>-</td>
<td>analyze different regulatory strategies using real-world cases</td>
<td></td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>• The regulatory landscape – a challenge for all players</td>
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<td></td>
<td></td>
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<tr>
<td>-</td>
<td>Different types of medicinal products - different regulatory pathways</td>
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<td></td>
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<tr>
<td>-</td>
<td>Health authorities – friend or foe?</td>
<td></td>
<td></td>
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<tr>
<td>-</td>
<td>Different countries – different regulations</td>
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<tr>
<td>-</td>
<td>Successful regulatory strategy – make or break for a medicinal product</td>
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<tr>
<td>-</td>
<td>From idea to product – do it yourself</td>
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</tr>
</tbody>
</table>

| 395-0201-00L | Regulatory Thinking        | O    | 2 credits | 4G    | D. Schaffarczyk, R. Abächerli, further lecturers |
| **Abstract** | Students gain an overview of how to transform a research idea into a finished healthtech product by confidently navigating different regulatory landscapes and developing compelling certification strategies for various healthtech products. Students learn how to use Regulatory Thinking to turn Regulatory Affairs into a business planning tool. |
| **Objective** | - Applying of regulatory thinking and translation of this method into practice. |
| - | Getting an overview of applicable laws, different regulations, directives and guidelines in the healthtech sector: MD, IVD, SaMD, medicine, biotech, ATMP. |
| - | Understanding the different roles and responsibilities of Certification Bodies (CB), Notified Bodies (NB), and other Regulators and/or Reimbursement Agencies, hereafter: Competent Authorities (CAs). |
| - | Knowing how to address CAs, including communication and interaction |
| - | Awareness of the importance of a quality management system (QMS) and knowing different systems, including, but not limited to ISO 13485:2016, GMP, GLP, GCP |
| **Content** | The journey of regulatory thinking - from medical devices (MDs), to in vitro diagnostics (IVDs), to software as a medical device (SaMD), to medicines and advanced therapeutic medicinal products (ATMPs): Commonalities, differences and the search for the lowest common denominator in terms of: |
| - | Regulations/Directives/Laws/Guidelines |
| - | Interaction with the regulatory authorities |
| - | The principles of safety/efficacy/performance/transparency |
| - | The requirements for the implementation of a QMS |

| 395-0202-00L | Intended Use / Indication   | O    | 2 credits | 4G    | D. Schaffarczyk, R. Abächerli, further lecturers |
| **Abstract** | From software as a medical device to medicinal products: The intended use of a healthtech product serves as strategic pivotal point from conception to reimbursement strategies: Understanding its importance defines advertising claims and ensures that the product meets the needs of patients. |
| **Objective** | Know and understand different definitions: medical need / public health assessment; personalized medicine, pharmacogenomics/ customized device. |
| - | Understand the importance of medical and stakeholder needs assessments in medicine / medtech / in-vitro diagnostics / software as medical device / artificial intelligence and among different stakeholders. |
| - | Understand the relationship between indication / intended use / intended purpose and development, including risk assessment. |
| - | Define the intended use / intended purpose for a healthtech product and derive user groups, patient groups, indications and contra-indications. |
| - | Understand and derive an overview of the different stakeholders of a healthtech product and their different interests. |
| - | Overview of different development models, starting with requirements engineering, the classical waterfall model and V-model up to agile methods for software as medical device or AI concepts. |
| - | ISO 14971: Understanding and applying principles of risk man-agement. |
| - | IEC 62366: Understanding and applying the principles of usability engineering. |
| - | Artificial Intelligence: Know the challenges of artificial intelligence in healthtech products, define an AI policy and develop a verification process. |
Content
The intended use is the "linchpin" in the development, approval and reimbursement of medicinal products or medical devices: Whether software as a medical device, artificial intelligence in medical devices, but also in pharmaceuticals or biotechnology, the intended use is the first and last touchstone - alpha and omega - of all healthtech concepts.

- Intended use, user and patient groups I/III: How the intended use of a healthtech product influences its development, safety, performance, marketing strategy and reimbursement possibilities.

- Intended use, user and patient groups II/III: How the intended use of a healthtech product determines the patient population and thus defines indications and contraindications.

- Intended use, user and patient groups III/III: How the intended use of a healthtech product determines the requirements for different user groups.

- Software as a medical device or drug: What is the market missing - what does the patient want? Derive product re-requirements by understanding market requirements and patient needs. (development planning).

- Software as a medical device or drug: Who is interested in the product, who benefits from it, who works with it? Derive concepts for usability and risk management by understand-ing the different user groups and their interests (verification and validation).

- Software as a medical device or drug: artificial intelligence, digital biomarkers, new biotech concepts: development and market-ing in compliance with regulations by applying "existing" standards to future technologies (regulatory compliance / legal compliance).

395-0204-00L Development Process: Preclinical W 2 credits 4G A. Krieg, L. Fischer

Abstract
An overview of the preclinical development of drugs as well as medical devices and in vitro diagnostics is given. The relevant regulations are conveyed in a practice-oriented manner.

Objective
- Understanding the principles and limitations of the preclinical efficacy and safety disciplines in product development - pharmacodynamics, pharmacokinetics and toxicology
- Understanding and apply regulations for drug development, development of medical devices and in vitro diagnostics
- Understanding for which purposes GLP (Good Laboratory Practice) is applied
- Understanding and apply the do's and don'ts of animal experiments in product development
- Understanding the different possibilities and the importance of communication with the regulatory authority in early product development

Content
The Module 4 "Development Process: Preclinical" includes an overview of preclinical efficacy and safety in drug development as well as in the development of medical devices and in vitro diagnostics. Emphasis will be placed on the applicable regulations and potential interactions with regulatory authorities in early product development. When a preclinical development plan becomes necessary and what is needed to start with will be explained in a practical way. An overview is also given of which preclinical studies and documents are required in order to be able to conduct an early clinical study in humans for the first time.

CAS in Regulatory Thinking - Key for Type

| O | Compulsory |
| W+ | Eligible for credits and recommended |
| W | Eligible for credits |
| E- | Recommended, not eligible for credits |
| Z | Courses outside the curriculum |
| Dr | Suitable for doctorate |

Key for Hours

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |
| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## CAS in Robotics

### Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>172-0100-00L</td>
<td>CAS Module in Robotics and AI</td>
<td>O</td>
<td>12 credits</td>
<td>26A</td>
<td>Professors</td>
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</tbody>
</table>

**Abstract**

In the CAS Robotics participants are offered a RobotX professor as a mentor together with whom they design their study plan along an individually-specified focus area in the area of Robotics and AI. Based on the individual expertise and interests of the participants, the customised Robotics and AI module consists of a combination of (i) research project, (ii) lectures, (iii) knowledge transfer.

**Objective**

The CAS Robotics and AI module offers experienced industry individuals the opportunity to undergo research-related training in Robotics and AI, to update their knowledge and to expand their area of expertise in a targeted manner and aims at:

- training skills at the frontiers of the current state of research in Robotics and AI,
- deepening technical know-how with state-of-the-art knowledge in the specified focus area, and
- advancing practical competencies in the impart of expertise and knowledge transfer across disciplines and educational levels.

**CAS in Robotics - Key for Type**

<table>
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<tr>
<th>O</th>
<th>Compulsory</th>
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<tbody>
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**Key for Hours**

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</table>

| P  | practical/laboratory course |
| A  | independent project |
| D  | diploma thesis |
| R  | revision course / private study |

**ECTS**

- European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# CAS in Seismic Evaluation and Retrofitting

*Offered only in the Autumn Semester.*

## Module

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>139-0101-00L</td>
<td>Module 1: Introduction to Seismic Design and Swiss Seismic Code Provisions</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>B. Stojadinovic</td>
</tr>
<tr>
<td>Abstract</td>
<td>The objective of this Module is to introduce the principles of Seismic Design of Structures and the Swiss Seismic Code Provisions to Civil Engineers working in Switzerland.</td>
<td></td>
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</tr>
</tbody>
</table>
| Objective  | This module enables participants:  
- To understand the critical points of the Swiss Code Provisions for the seismic design of new structures and the seismic evaluation of existing structures  
- To get an overview in the dynamics and the principles of seismic design of structures |
| Content    | 1.1 Introduction to seismic hazard and seismic risk, seismic performance objectives, common structural deficiencies and observed damage patterns due to earthquake ground motion excitation  
1.2 Seismic elastic and inelastic response of SDOF systems and earthquake response spectra  
1.3 Seismic elastic and inelastic response of MDOF systems, Response Spectrum Analysis and Pushover Analysis  
1.4 Seismic Design of structures using SIA 261: Presentation and Examples  
1.5 Good practices for the seismic design of new structures  
1.6 Seismic safety of non-structural components  
1.7 Swiss Code Provisions for the seismic evaluation of existing structures SIA 269/8: Presentation and examples, Evaluation of commensurability of seismic retrofitting measures |
| Prerequisites / notice | - Anwesenheit (mind. 80% pro Präsenzwoche) und aktive Mitarbeit in den Präsenzwochen  
- mindestens genügende Leistungen bei Leistungskontrollen |

| 139-0102-00L | Module 2: Finite Element Modelling and Identification of the Seismic Behavior of Structures | O    | 2 credits | 3G   | B. Stojadinovic |
| Objective    | This module enables participants:  
- To use the state-of-the-art FEM software and implement the optimal FE modelling techniques for the simulation of the seismic response of existing buildings (concrete, masonry, mixed concrete-masonry) located in Switzerland  
- To obtain knowledge of the FEM software and the modelling techniques for the simulation of soil-structure interaction  
- To understand the current methodologies for the identification and monitoring of the vibration and the seismic behavior of structures located in Switzerland. |

| 139-0103-00L | Module 3: Analysis Methods and Case Study Examples of Seismic Evaluation and Retrofitting | O    | 2 credits | 3G   | B. Stojadinovic |
| Abstract     | The scope of this Module is to present Analysis Methods and Case Study Examples that illustrate established procedures and practical engineering solutions that are applied in the seismic evaluation and retrofitting of existing structures by Civil Engineers working in Switzerland. |
| Objective    | This module enables participants:  
- To acquire practical knowledge of the seismic retrofitting techniques commonly used in Switzerland, their implementation and their cost  
- To select the appropriate analysis method for the seismic evaluation of structures located in Switzerland and understanding of the governing factors |

| 139-0104-00L | Module 4: Individual Project Exercise | O    | 4 credits | 2P   | B. Stojadinovic |
| Objective    | This modules enables participants  
- To conduct independently a seismic evaluation of an existing structure located in Switzerland considering the boundary conditions that influence the seismic behavior of the structure |

## CAS in Seismic Evaluation and Retrofitting - Key for Type

<table>
<thead>
<tr>
<th>O</th>
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<tbody>
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<tr>
<td>E-</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</tbody>
</table>

## Key for Hours

| V          | lecture                                                                  |
| G          | lecture with exercise                                                   |
| U          | exercise                                                                |
| S          | seminar                                                                 |
| K          | colloquium                                                              |
| P          | practical/laboratory course                                             |
| A          | independent project                                                    |
| D          | diploma thesis                                                         |
| R          | revision course / private study                                         |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Technology and Public Policy: Impact Analysis
Two-yearly recurring programme, offered only in spring semester. The programme is offered again the spring semester of 2026.

Economic Foundations for Policy Analysis
Two-yearly recurring programme, offered only in spring semester. The programme is offered again in the spring semester of 2026.

Module Technology and Policy Analysis

Module Policy-Making in Practice

<table>
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<tr>
<th>CAS in Technology and Public Policy: Impact Analysis - Key for Type</th>
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ECTS European Credit Transfer and Accumulation System

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CAS in Technology and Public Policy: Policy Process
Two-yearly recurring programme, offered only in spring semester. The programme is offered again in the spring semester of 2025.

- Module Technology, Society, Markets, and the State
- Module Public Sphere and Stakeholders in Policy-Making
- Module Communication and Negotiation

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<td>D</td>
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<tr>
<td>R</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Future of Spatial Development

Introduction

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>135-0001-00L</td>
<td>Introduction: Basics of Spatial Planning</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Kissling, A. Rupf, J. Van Wezemael</td>
</tr>
</tbody>
</table>

Abstract

Orientation and preparation for further education in the field of spatial planning and development. Introduction to the Spatial Planning Act and its instruments, assessment of participants’ knowledge. Completion through mandatory assessment.

Future of Spatial Development

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>135-0301-00L</td>
<td>Modul 1: Urbane Zukunft</td>
<td>O</td>
<td>2 credits</td>
<td>1G</td>
<td>A. Rupf, J. Da Cruz Paulos, J. Van Wezemael</td>
</tr>
<tr>
<td>135-0302-00L</td>
<td>Modul 2: Digitale und operative Kompetenz</td>
<td>O</td>
<td>2 credits</td>
<td>1G</td>
<td>A. Rupf, N. C. Neubert, to be announced</td>
</tr>
<tr>
<td>135-0303-00L</td>
<td>Modul 3: Landschaft und Ökosysteme</td>
<td>O</td>
<td>2 credits</td>
<td>1G</td>
<td>A. Rupf, A. Grêt-Regamey, M. Pütz</td>
</tr>
<tr>
<td>135-0304-00L</td>
<td>Modul 4: Nachhaltige Mobilität</td>
<td>O</td>
<td>2 credits</td>
<td>1G</td>
<td>A. Rupf</td>
</tr>
<tr>
<td>135-0305-00L</td>
<td>Modul 5: Transformation gestalten:</td>
<td>O</td>
<td>2 credits</td>
<td>1G</td>
<td>A. Rupf, J. Da Cruz Paulos, D. Kaufmann</td>
</tr>
<tr>
<td></td>
<td>Veränderungsprozesse &amp; Change-Management</td>
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<tr>
<td>135-0306-00L</td>
<td>Design Studio</td>
<td>O</td>
<td>5 credits</td>
<td>5G</td>
<td>A. Rupf, E. Cello, S.-E. Rabe, J. Van Wezemael</td>
</tr>
</tbody>
</table>

Key for Hours

| V | lecture          | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise         | D | diploma thesis |
| S | seminar          | R | revision course / private study |
| K | colloquium       |    |                            |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Chemistry (General Courses)

### General Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0499-00L</td>
<td>Physical Chemistry</td>
<td>Z</td>
<td>0 credits</td>
<td>1K</td>
<td>R. Signorell, M. Ernst, P. H. Hünenberger, H. J. Wörner</td>
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<tr>
<td></td>
<td>Institute-Seminar covering current research Topics in Physical Chemistry</td>
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<td>529-0688-00L</td>
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<td>MPS Colloquium</td>
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<td>G. Jeschke, A. Barnes, M. Ernst, P. H. Hünenberger, F. Merkt, M. Reiher, J. Richardson, R. Riek, S. Riniker, T. Schmidt</td>
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<td>Seminar series covering current developments in Molecular Physical Science</td>
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<td>Discussing current developments in Molecular Physical Science</td>
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<td>Self-direction and Self-management</td>
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### Key for Type

- **G**: Compulsory
- **W+**: Eligible for credits and recommended
- **W**: Eligible for credits
- **E-**: Recommended, not eligible for credits
- **Z**: Courses outside the curriculum
- **Dr**: Suitable for doctorate

### Key for Hours

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium
- **P**: practical/laboratory course
- **A**: independent project
- **D**: diploma thesis
- **R**: revision course / private study

### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Chemistry Bachelor

1. Semester

Compulsory Subjects First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<td>529-0011-02L</td>
<td>General Chemistry (inorganic Chemistry) I</td>
<td>O</td>
<td>3 credits</td>
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<td>A. Togni</td>
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<td>Abstract</td>
<td>Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions</td>
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<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
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<td>Content</td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
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<td>P. Chen</td>
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<tr>
<td>Abstract</td>
<td>Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions.</td>
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<td>Objective</td>
<td>Introduction to the structures of organic compounds as well as the structural and energetic basis of organic chemistry.</td>
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<td>Content</td>
<td>Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topology, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intermolecular interactions.</td>
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<td>Lecture notes</td>
<td>Underlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt</td>
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<td>H. J. Wörner</td>
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<td>Abstract</td>
<td>The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.</td>
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<td>Objective</td>
<td>After the lecture, students will be able to,</td>
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<td>- to calculate physical quantities and their units which are important for chemistry,</td>
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<td>- name some properties of chemically relevant particles and propose experimental methods to determine these properties,</td>
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<td>- name applications and hazards of radioactivity,</td>
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<td>- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,</td>
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<td>- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,</td>
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<td>- independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems,</td>
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<td>- model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model,</td>
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<td>- explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom,</td>
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<td>- explain the structure of the periodic table of elements with the help of the orbital concept,</td>
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<td>- recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and</td>
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<td>- establish term symbols for atomic ground states.</td>
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<td>Content</td>
<td>Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions, Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.</td>
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<tr>
<td>Lecture notes</td>
<td>See homepage of the lecture.</td>
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Mathematical Foundations I: Analysis A

Abstract
Introduction to calculus in one dimension. Building simple models and analysing them mathematically. Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

Objective
Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

Content
Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

Literature
G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag
R. Sperb/M. Akveld: Analysis I (vdf)
L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg

Competencies
- Subject-specific Competencies:
  - Concepts and Theories: fostered
  - Techniques and Technologies: assessed

- Method-specific Competencies:
  - Problem-solving: fostered

- Personal Competencies:
  - Critical Thinking: fostered

401-0271-00L
Introduction to Computer Science

Abstract
Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.

Objective
Acquire a starting package concerning the computational aspects of natural sciences; discuss fundamentals of computer architecture, languages, algorithms and programming with an eye to their application in the area of chemistry, biology and material science.

Content
Lecture: Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation; Exercises: Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

Literature
- Script booklet (copies of powerpoint slides, in English), distributed at first or second lecture.
- See: www.csms.ethz.ch/education/Infol

Prerequisites / notice
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the written exam, the results of the exercises are taken into account when evaluating the results of the exam (compulsory performance component, 12% of the exam mark; in case of repetition of the exam, the exercise marks from a previous semester can be kept).

For more information about the lecture: www.csms.ethz.ch/education/Infol

Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Lecturers</th>
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<td>529-0011-04L</td>
<td>Practical Course General Chemistry ■</td>
<td>O</td>
<td>8</td>
<td>12P</td>
<td>M. Bezdek, D. Dirin, T. Segawa, A. Yakimov</td>
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Information about the practical course will be given on the first day.

Abstract
The general chemistry practical course aims at preparing the students for the work in modern chemistry laboratory. The students are trained to behave safely in the laboratory and use chemicals, chemistry glassware, and related equipment to perform and analyze the equilibrium in basic chemical reactions.

Objective
The students are expected to gain practical experience with as well as establish understanding of the following concepts and phenomena:
- Safe behavior and safety regulations in chemistry laboratory;
- Best practices in common techniques (purification, recrystallization, distillation, etc.);
- Analysis of measured values (measuring error, average value, error analysis);
- Acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems);
- Precipitation equilibria (gravimetry, potentiometry, conductivity measurements);
- Oxidation state and redox reactions (redox-titrations, galvanic elements);
- Metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration);
- Qualitative analysis (cation and anion separation, determination of cations and anions).
In the general chemistry practical course students are introduced to the work in chemistry laboratory. During the course they become familiar with common chemistry glassware and related equipment as well as learn basic experimental procedures, such as distillation, recrystallization, purification, digestion etc. Upon the measurements of \( \text{pH} \), conductivity, and potential in the course of reactions, students establish the understanding of the chemical equilibrium concept.

Students work with various classes of inorganic compounds and types of chemical reactions, e.g. acid-base, redox, precipitation. They also obtain first experience with the synthesis of metal complexes as well as learn basics of qualitative analysis of an unknown substance.

### Competencies

<table>
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<tr>
<th>Competency Type</th>
<th>Competency Area</th>
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<tr>
<td>Personal</td>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
</tr>
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<td>Critical Thinking</td>
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<td>Personal</td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal</td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
</tr>
</tbody>
</table>

### Literature


### Prerequisites / Notice

Compulsory: online enrolment latest one week after start of the semester

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.

### 3. Semester

#### Compulsory Subjects Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0121-00L</td>
<td>Inorganic Chemistry I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>P. Steinegger, V. Mougel</td>
</tr>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>R. Signorell</td>
</tr>
</tbody>
</table>

### Abstract

- **Inorganic Chemistry I**: Discussion of syntheses, structures, and general reactivity of coordination compounds of the transition metals (as well as the lanthanides and actinides). Introduction of methods of characterization and physicochemical properties of coordination compounds.


### Objective

- The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to explain the structure, chemical bonding, spectroscopic properties as well as general strategies for the synthesis of complexes of transition metals. In this context, students will master the basics of group theory and its application.

- The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) vibrational spectroscopy; 9) electronic excitation.

### Content

- **Inorganic Chemistry I**: 1) General definitions and terms in coordination chemistry; 2) Coordination numbers and structures; 3) Ligand types; 4) The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 5) The chemical bond in coordination compounds part B: Qualitative MO theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) vibrational spectroscopy; 9) electronic excitation.

### Literature

401-0373-00L  Mathematics III: Partial Differential Equations  O  4 credits  2V+1U  N. Moshayedi

**Abstract**

**Objective**
Classical tools to solve the most common linear partial differential equations.

**Content**

1) Examples of partial differential equations
   - Classification of PDEs
   - Superposition principle

2) One-dimensional wave equation
   - D'Alembert's formula
   - Duhamel's principle

3) Fourier series
   - Representation of piecewise continuous functions via Fourier series
   - Examples and applications

4) Separation of variables
   - Solution of wave and heat equation
   - Homogeneous and inhomogeneous boundary conditions
   - Dirichlet and Neumann boundary conditions

5) Laplace equation
   - Solution of Laplace's equation on the rectangle, disk and annulus
   - Poisson formula
   - Mean value theorem and maximum principle

6) Fourier transform
   - Derivation and definition
   - Inverse Fourier transform and inversion formula
   - Interpretation and properties of the Fourier transform
   - Solution of the heat equation

7) Laplace transform (if time allows)
   - Definition, motivation and properties
   - Inverse Laplace transform of rational functions
   - Application to ordinary differential equations

**Lecture notes**
See the course web site (linked under Lernmaterialien)

**Literature**

Additional books:
4) E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1,2,11,12,8)

For additional sources, see the course web site (linked under Lernmaterialien)

**Prerequisites / notice**
Required background:

1) Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant
2) Multiple integrals: Riemann integrals in two or three variables, change of variables
3) Basic knowledge of ordinary differential equations

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**Compulsory Subjects Examination Block I**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>
| 529-0221-00L | Organic Chemistry I | O    | 3     | 2V+1U | H. Wennemers     

**Abstract**
This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

**Objective**
The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.

**Content**

**Lecture notes**
The lecture slides, problem sets, and additional documents are provided online. Link: https://wennemers.ethz.ch/education.html
Literature

529-0051-00L Analytical Chemistry I
3 credits 3G D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi

Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.
- UV/VIS spectroscopy: Basics, interpretation of electron spectra. Circular dichroism (CD) and optical rotation dispersion (ORD).

Lecture notes
Script will be for the production price

Literature
- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995

Prerequisites / notice
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

Laboratory Courses

Number Title Type ECTS Hours Lecturers
529-0129-00L Inorganic and Organic Chemistry II 11 credits 16P V. Mougel

Abstract
Introduction to the experimental methods of Inorganic Chemistry

Objective
The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc. The synthesis, characterization and analysis of inorganic compound are a main topic. Special emphasis on experimental techniques of synthetic inorganic chemistry, in particular the safe handling of reactive and pyrophoric chemical and solvent purification and drying techniques.

Content
Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra.

Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

Lecture notes
A manual is distributed in the teaching laboratory.

Prerequisites / notice
- Passed Basisprüfung
- Passed Practical Course General Chemistry (1. Semester, 529-0011-04)
- Passed Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230) or Practical Course BCB III: Organic Chemistry (3. Sem. BSc BCB, 529-0016-00)
- Continuous Attendance of Course Inorg. and Org. Chemistry I (2. Sem., 529-0230) or Practical Course BCB III: Organic Chemistry (3. Sem. BSc BCB, 529-0016-00)
- Continuous Attendance of Course General Chemistry (1. Semester, 529-0011-04)

This class has a limited number of positions available. If necessary, access priority will be settled according to the results of the first-year examinations. Students that are not accepted following that rule will be given priority for the coming year registration.

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

5. Semester
Compulsory Subjects Examination Block III

Number Title Type ECTS Hours Lecturers
529-0132-00L Inorganic Chemistry III: Organometallic Chemistry and O 4 credits 3G M. Bezdek, C. Copéret

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 528 of 2667
Homogeneous Catalysis

Abstract
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carboxylation, C-C bond-forming and related reactions.

Objective
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

Content
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carboxylation, C-C bond-forming and related reactions.

529-0231-00L Organic Chemistry III: Introduction to Asymmetric Synthesis

Abstract
Methods of Asymmetric Synthesis

Objective
Understanding of the basic principles of diastereoselective synthesis

Content
Conformational analysis: acyclic and cyclic systems; Diastereoselective sigmatropic rearrangements; Diastereoselective Carbolnyl addition reactions; Cram- and Felkin-Anh models, carbonyl Lewis acid interactions, chelate controlled reactions; chemistry of enolates, selective formation; asymmetric enolate alkylation; aldol reactions, allyl- and crotyl-metal chemistry; cyclisations, Baldwin rules; Diastereoselective olefin functionalization: hydroboration, dihydroxylation, epoxidation.

Literature

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

529-0432-00L Physical Chemistry IV: Magnetic Resonance

Abstract
Theoretical foundations of magnetic resonance (NMR, EPR) and selected applications.

Objective
Introduction to magnetic resonance in isotropic and anisotropic phase.

Content
The course gives an introduction to magnetic resonance spectroscopy (NMR and EPR) in liquid, liquid crystalline and solid phase. It starts from a classical description in the framework of the Bloch equations. The implications of chemical exchange are studied and two-dimensional exchange spectroscopy is introduced. An introduction to Fourier spectroscopy in one and two dimensions is given and simple 'pulse trickery' is described. A quantum-mechanical description of magnetic resonance experiments is introduced and the spin Hamiltonian is derived. The chemical shift term as well as the scalar, dipolar and quadrupolar terms are discussed. The product-operator formalism is introduced and various experiments are described, e.g. polarization transfer. Applications in chemistry, biology, physics and medicine, e.g. determination of 3D molecular structure of dissolved molecules, determination of the structure of paramagnetic compounds and imaging (MRI) are presented.

Lecture notes
handed out in the lecture (in english)

Literature
see http://www.ssnmr.ethz.ch/education/PC_IV_Lecture

529-0449-00L Spectroscopy

Abstract
Laboratory experiments to acquire a profound knowledge of spectroscopical methods and techniques in chemistry. Evaluation and visualization of measurement data. Writing lab reports.

Objective
Laboratory experiments to acquire a profound knowledge of spectroscopical methods and techniques in chemistry. Evaluation and visualization of measurement data. Writing lab reports.

Content
Laboratory experiments: UV/VIS spectroscopy, luminescence spectroscopy, FT infrared spectroscopy, light diffraction and refraction, thermal lenses, Raman spectroscopy, reflection spectroscopy, optical polarization phenomena, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), FT nuclear magnetic resonance spectroscopy (NMR), electron paramagnetic resonance spectroscopy (EPR), atomic force microscopy (AFM), Fourier transform methods.

Lecture notes
Detailed documentations to each experiment will be handed out.

Prerequisites / notice
Praktikum Physikalische Chemie, 3. Auflage, vdf Hochschulverlag an der ETH, Zürich 2022.
Praktikum Physikalische Chemie (529-0054-00) or Praktikum Physikalische Chemie (529-0054-01).

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.
Competencies

Subject-specific Competencies

Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies

Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered

Project Management fostered

Social Competencies

Communication fostered
Cooperation and Teamwork fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

Electives

Students are free to choose from a range of D-CHAB chemistry courses appropriate to their level of study (please note admission requirements). In case of doubt, contact the student administration.

Inorganic Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0141-00L</td>
<td>Physical Methods for Inorganic Chemistry</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>M. D. Wörle, D. Günther, J. Koch, R. Verel</td>
</tr>
</tbody>
</table>

Abstract
Introduction into the important methods for structural analysis (solid state NMR), crystal structure analysis and surface analysis techniques and their applications

Objective
Knowledge in solid state NMR, crystal structure analysis and surface analytical techniques relevant for inorganic materials

Content
This lecture course consists of three parts 1) Solid-state NMR 2) Surface and direct solid analysis 3) Crystal structure analysis. Most important fundamentals of the individual methods will be presented and details will be explained on most relevant inorganic applications

Lecture notes
Will be given during the lectures

Physical Chemistry

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>529-0441-00L</td>
<td>Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>F. Merkt, U. Hollenstein</td>
</tr>
</tbody>
</table>

Abstract
Introduction of the basics of signal processing in spectroscopy. Fourier transformation, linear response theory, stochastic signals, digital data processing, Fourier spectroscopy.

Objective
Basics of signal processing in spectroscopy

Content

Analytical Chemistry

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>529-0041-00L</td>
<td>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano</td>
</tr>
</tbody>
</table>

Abstract
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Lecture notes
Lecture notes will be made available online.

Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

Prerequisites / notice
Exercises are an integral part of the lecture.

Prerequisites:
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)
**Biological Chemistry**

<table>
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<tr>
<th>Number</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>529-0240-00L</td>
<td>Chemical Biology - Peptides</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>H. Wennemers</td>
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<tr>
<td>Abstract</td>
<td>An advanced course on the synthesis, properties and function of peptides in chemistry and biology.</td>
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<tr>
<td>Objective</td>
<td>Knowledge of the synthesis, properties and function of peptides in chemistry and biology.</td>
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<tr>
<td>Content</td>
<td>Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.</td>
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<tr>
<td>Lecture notes</td>
<td>Citations from the original literature relevant to the individual lectures will be assigned weekly.</td>
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<tbody>
<tr>
<td>529-0731-00L</td>
<td>Nucleic Acids and Carbohydrates</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>K. Lang, M. Frei, P. A. Kast,</td>
</tr>
<tr>
<td>Abstract</td>
<td>Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines.</td>
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<tr>
<td>Objective</td>
<td>Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines.</td>
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<tr>
<td>Content</td>
<td>Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines.</td>
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<tr>
<td>Lecture notes</td>
<td>No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).</td>
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<tr>
<td>Literature</td>
<td>Mainly based on original literature, a detailed list will be distributed during the lecture</td>
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</table>

**Chemical Aspects of Energy**

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<th>Number</th>
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<tbody>
<tr>
<td>529-0659-00L</td>
<td>Electrochemistry: Fundamentals, Cells &amp; Applications</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>L. Gubler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics &amp; kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion.</td>
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<tr>
<td>Objective</td>
<td>The course establishes the fundamentals to understand and describe electrochemical reactions and phenomena related to these. The students are familiarized with key concepts and approaches in electrochemistry and selected aspects of materials science and engineering and how they are put to use in selected applications.</td>
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</table>
Content

- Introduction: important quantities & units, terminology;
- Chapter I - Redox reactions, Faraday's laws;
- Chapter II - Equilibrium electrochemistry: cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces: electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes: conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry: overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry: electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion: important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors: potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion: corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

Lecture notes
lecture notes, lecture slides, exercise & solutions (PDF files)

Literature
[German version available as well]

Prerequisites / notice
Students should be familiar with the fundamentals of physical chemistry.

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
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<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<td>Personal Competencies</td>
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Chemical Crystallography

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0039-00L</td>
<td>Principles of Crystal Structure Determination</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>M. D. Wörle, N. Trapp</td>
</tr>
</tbody>
</table>

Abstract
An introduction to the principles of X-ray diffraction and crystal structure determination as it relates to Chemistry

Objective
To gain an understanding of the principles of crystal structure determination by X-ray diffraction.

Content
Basic crystallographic concepts: Unit cells, Bravais lattices, Laue symmetry, crystal classes (point groups), space groups, crystal growth, instrumentation, diffraction of X-rays by crystals: physical and geometric basics, powder and single crystal methods, structure solution and modelling, interpretation of crystal structure data: internal coordinates for structure description: atom spacing, co-ordination polyhedra, bond angles, torsion angles; intermolecular interactions, absolute configuration determination. Overview of inorganic, organic and macromolecular databases.

Lecture notes
The script and exercises will be distributed weekly in loose form
### Computational Chemistry

**Number Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | ---
529-0002-00L Algorithms and Programming for Chemistry | W | 6 credits | 3G | S. Riniker, G. Landrum

**Abstract**
Introduction to algorithms (special focus on chemistry):
Design of algorithms, data structures, search and sort algorithms, graphs, numerical algorithms, algorithms in cheminformatics, machine learning and bioinformatics

**Objective**
Development of programming skills and craftsmanship in order to be able to deal with the complexity of computer applications in chemistry.

**Content**
Introduction to algorithms (special focus on chemistry):
Design of algorithms, data structures, search and sort algorithms, graphs, numerical algorithms, algorithms in cheminformatics, machine learning and cheminformatics

**Lecture notes**
Script (in English) will be available

**Literature**

- C++ programming:

**Prerequisites / notice**
Since the exercises on the computer do convey and test essentially different skills as those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Media and Digital Technologies: assessed

- **Personal Competencies**
  - Adaptability and Flexibility: fostered
  - Critical Thinking: fostered
  - Self-direction and Self-management: fostered

### Materials Science

**Offered during Spring Semester.**

**Number Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | ---
327-0312-00L Materials Synthesis I - Polymers | W | 4 credits | 4G | A. Anastasaki, D. Opirs

**Abstract**
The course teaches the basics and terminology of polymer synthesis. To synthesize various polymeric materials, different polymerization techniques are required. This course will introduce representative polymerization methodologies and will discuss how they operate in order to yield materials with enhanced polymeric characteristics.

**Objective**
1) The students will be able to recognize different polymer types and associate them with their chemical structure and properties (i.e. rubber elasticity, glass transition temperature, etc.)
2) The students will become familiar with various synthetic methods to produce polymers of different architectures and topologies
3) The students will be exposed to different characterization methods (e.g. size exclusion chromatography, mass-spectrometry, nuclear magnetic resonance) that are necessary to confirm the successful synthesis and structure of a polymer
4) The students will understand the mechanism of selected polymerization methodologies
5) The students will be introduced to state-of-the-art polymer synthesis and recent literature examples will be critically discussed

**Content**
conventional chain growth polymerization, living chain growth polymerization, step growth polymerization, polymeric architectures, molecular weight determination methods, polymer properties, polymerization mechanisms, polymer characterization methods

**Lecture notes**
Lecture slides with references to further literature will be available on Moodle

**Literature**
L. Mandelkern, “An Introduction to Macromolecules”
J. M. G. Cowie “Polymers: Chemistry and Physics of Modern Materials”
Publications mentioned on the slides

### Environmental Chemistry

**Number Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | ---
529-0037-01L Introduction to Environmental Chemistry and Ecotoxicology | W | 4 credits | 3G | J. Hollender, T. Hofstetter, C. S. McArdell

**Abstract**
What happens to chemicals in the environment? How do we determine whether they degrade over decades and accumulate in the food chain? Answers to these questions are provided in this lecture, which covers basic knowledge about distribution behavior, environmental analysis, abiotic and biotic degradation reactions, and toxic effects of chemicals as part of environmental chemical risk analysis.
**Objective**

Students will develop a basic understanding for fate and effects of chemicals in the environment and learn how to use simple quantitative tools for the assessment of chemical behaviour and toxic effects.

**Content**

Part 1: Partitioning and reactivity
- Physico-chemical description of partitioning behaviour of organic compounds
- Partitioning in environmental media including soil/sediment, air, water
- Chemical and biological transformations

Part 2: Effects
- Test systems for the assessment of ecotoxicological effects of chemicals
- Bioavailability and bioaccumulation
- Metabolisms of organic compounds
- Molecular mechanisms of toxic action

Part 3: Analyses
- Analytical methods for quantification of substances in water, soil, and air
- Sampling, sample preparation and quantification of organic compounds in environmental media

**Lecture notes**

Handouts/lecture slides will be made available electronically.

**Literature**

Fent, Ecotoxicology, Thieme, 4. Auflage, 2013
Campbell et al., Ecotoxicology, Cambridge University Press, 2022

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>assessed</td>
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<td>assessed</td>
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</tr>
<tr>
<td>assessed</td>
<td>fostered</td>
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</table>

**Economics**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>B. Clarysse, S. Brusoni, V. Hoffmann, T. Netland</td>
</tr>
</tbody>
</table>

**Abstract**

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

**Objective**

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

**Content**

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

**Competencies**

<table>
<thead>
<tr>
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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
</tbody>
</table>
| assessed                     | fostered                     | fostered           |自负

**Science in Perspective**
### Science in Perspective

*see Science in Perspective: Type A: Enhancement of Reflection Capability*

*Recommended Science in Perspective (Type B) for D-CHAB*

### Language Courses

*see Science in Perspective: Language Courses ETH/UZH*

#### Chemistry Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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</table>

#### Key for Hours

<table>
<thead>
<tr>
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<th>Type</th>
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</thead>
<tbody>
<tr>
<td>V</td>
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</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under guidance, students create materials for chemistry classes that are effective for learning.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving

- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Self-direction and Self-management

![Table](image)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0959-00L</td>
<td>Mentored Work Subject Didactics Chemistry A</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>A. Zwyssig</td>
</tr>
<tr>
<td>529-0960-00L</td>
<td>Mentored Work Subject Didactics Chemistry B</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>A. Zwyssig</td>
</tr>
</tbody>
</table>
### Professional Training in Chemistry

**Important Notice:** Enrolment in the courses of this category is only possible if no more than 12 CP of potential additional requirements have to be acquired.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0966-00L</td>
<td>Introductory Internship Chemistry</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>P. Aschwanden</td>
</tr>
<tr>
<td>529-0964-00L</td>
<td>Teaching Internship Chemistry</td>
<td>O</td>
<td>8</td>
<td>17P</td>
<td>P. Aschwanden</td>
</tr>
</tbody>
</table>

#### Literature

- Die Studierenden beschaffen sich die Literatur in der Regel selber (siehe Lernziele).
- Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.
- The students have basic subject didactic knowledge for teaching chemistry at a secondary school.
- They are able to design lessons that are effective for learning, actively involve students in lessons, explain challenging concepts simply, use experiments for theory and reflect on teaching.
- They sit in on five lessons given by the teacher responsible for their teaching practice.
- The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

#### Prerequisites / notice

- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.
- They learn to assess pupils' work.
- They acquire the skills of the teaching trade.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- H.-J. Bader et al: Konkrete Fachdidaktik Chemie, Oldenbourg Verlag, 2002
- H.-J. Bader et al: Konkrete Fachdidaktik Chemie, Oldenbourg Verlag, 2002

#### Abstract

- Implementing findings from research into teaching and learning for chemistry lessons and coverage of subject-specific teaching and learning specialities.
- The students have basic subject didactic knowledge for teaching chemistry at a secondary school.
- They are able to design lessons that are effective for learning, actively involve students in lessons, explain challenging concepts simply, use experiments for theory and reflect on teaching.
- Schwerpunkte im ersten Studiensemester bilden die folgenden Themen:
  - Implementing findings from research into teaching and learning for chemistry lessons and coverage of subject-specific teaching and learning specialities.
  - The students have basic subject didactic knowledge for teaching chemistry at a secondary school.
  - They are able to design lessons that are effective for learning, actively involve students in lessons, explain challenging concepts simply, use experiments for theory and reflect on teaching.

#### Objective

- Wird von der Praktikumslehrperson bestimmt.
- Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.
- Das Einführungspraktikum findet an einem Gymnasium der Deutschschweiz statt.
- Der Chemieunterricht am Gymnasium soll einerseits grundlegende chemische Kenntnisse für den Alltag vermitteln und andererseits auf ein naturwissenschaftlich orientiertes Hochschulstudium vorbereiten. Diese beiden Ziele sind im Unterricht gleichermaßen zu berücksichtigen.
- Anhand der Diskussion bewährter Beispiele und dem Entwurf eigener Unterrichtsbausteine soll die zukünftige Lehrperson befähigt werden, einen den spezifischen Rahmenbedingungen angepassten Unterricht zu entwickeln, der diesem hohen Qualitätsanspruch genügt.

#### Content

- Das Einführungspraktikum gibt den Studierenden Einblick in den Berufsalltag einer Lehrperson.
- Wird von der Praktikumslehrperson bestimmt.
- Das Einführungspraktikum findet an einem Gymnasium der Deutschschweiz statt.

#### Literature

- Der Chemieunterricht am Gymnasium soll einerseits grundlegende chemische Kenntnisse für den Alltag vermitteln und andererseits auf ein naturwissenschaftlich orientiertes Hochschulstudium vorbereiten. Diese beiden Ziele sind im Unterricht gleichermäßen zu berücksichtigen.
- Anhand der Diskussion bewährter Beispiele und dem Entwurf eigener Unterrichtsbausteine soll die zukünftige Lehrperson befähigt werden, einen den spezifischen Rahmenbedingungen angepassten Unterricht zu entwickeln, der diesem hohen Qualitätsanspruch genügt.

#### Competencies

- Subject-specific Competencies | Concepts and Theories | fostered |
- Method-specific Competencies | Analytical Competencies | fostered |
- Personal Competencies | Adaptability and Flexibility | fostered |
- | Creative Thinking | fostered |
- | Self-direction and Self-management | fostered |

#### Prerequisites / notice

- Simultaneous enrolment in Subject Didactics Chemistry I
  - course 529-0950-00L - is compulsory.
- Simultaneous enrolment in Introductory Internship Chemistry - course 529-0966-00L - is compulsory.
- H.-J. Bader et al: Konkrete Fachdidaktik Chemie, Oldenbourg Verlag, 2002
- H.-J. Bader et al: Konkrete Fachdidaktik Chemie, Oldenbourg Verlag, 2002


Literatur

Prerequisites / notice
- Aufgaben zur Auswertung entwerfen
- Experimente in den Unterricht einbetten
- Auf Basis der Literatur ein Experiment selbständig ausarbeiten, dokumentieren und vorführen
- Experimente mit einer Skizze festhalten
- Die Studierenden erproben und demonstrieren bereitstehende Experimente
- Aus der Literatur ein Experiment selbständig ausarbeiten, dokumentieren und vorführen

Lecture notes

Examination Lesson I Chemistry

Simultaneous enrolment in "Examination Lesson II Chemistry" (529-0968-02L) is compulsory.

Will mark the conclusion of the teacher training program in Chemistry.

On the basis of a specified topic, the candidate shows that they are in a position to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle.

In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Simultaneous enrolment in "Examination Lesson II Chemistry" (529-0968-02L) is compulsory.

Will mark the conclusion of the teacher training program in Chemistry.

On the basis of a specified topic, the candidate shows that they are in a position to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle.

In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.
Mentored Work Specialised Courses in the Respective Subject with an Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0078-00L</td>
<td>Internship Chemistry Didactics</td>
<td>O</td>
<td>4</td>
<td>9P</td>
<td>P. Aschwanden</td>
</tr>
<tr>
<td>Abstract</td>
<td>During the Internship Chemistry Didactics students teach 8 lessons at a high school. Students try out and evaluate activating forms of instruction presented in the subject didactics.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Students will be able to use different didactic methods in the classroom and recognize the details necessary for successful implementation.</td>
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</tbody>
</table>

| 529-0962-00L | Fundamental Aspects of Chemistry with an Educational Focus I          | O    | 4    | 2V    | C. Thilgen, R. Grass, A. Togni |
| Abstract     | Selected topics in general chemistry:                                 |
|              | 1) The language of chemistry                                          |
|              | 2) Chirality and stereochemistry                                     |
|              | 3) Chemistry and sustainability.                                      |
| Content      | In this course, participants acquire extended and more in-depth knowledge of selected chemistry topics. The selection is based to a large extent on the partial aspects of chemistry that are typically taught at high school. By gaining a broader understanding, teachers are put in a position where they can comprehend the topics that are to be taught in a wider and, to some extent, unconventional context and critically process these in respect of their teachability and learnability. At the same time, interrelationships between the classical sub-disciplines of chemistry are highlighted, along with the unique features of chemistry as one of the central natural sciences. |

Learning format: Lecture.

Theme of focus of FV I:
- The language of chemistry: Concepts, formulas, aesthetics, and philosophical aspects
- Stereochemistry: The Coupe du Roi and its chemical meaning, Cyclostereoisomerism, Origin of biomolecular homochirality
  Chemistry and sustainability. The link between chemical products and energy consumption, life cycle assessments and chemical energy storage

Lecture notes: Slides and selected literature will be provided.

Literature: Selected articles from the primary literature are presented, commented on and recommended reading.

Prerequisites / notice: FV I (fall semester) and FV II (spring semester) do not build upon each other. The order in which they are taken is therefore indifferent.

Competencies:

Subject-specific Competencies: Concepts and Theories - assessed
Method-specific Competencies: Analytical Competencies - assessed
Social Competencies: Communication - fostered
Leadership and Responsibility - fostered
Sensitivity to Diversity - fostered

Personal Competencies: Creative Thinking - fostered
Critical Thinking - fostered
Self-awareness and Self-reflection - fostered

| 529-0962-01L | Mentored Work Specialised Courses in the Respective Subject with an Educational Focus II | O    | 4    | 4A    | A. Zwyssig                     |
| Abstract     | In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level. |
| Objective    | The aim is for the students                                           |
|              | - to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way. |
|              | - to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership. |
|              | - To try out different options for specialist further training in their profession. |
| Content      | Thematheische Schwerpunkte:                                          |

Lernformen:
- Die Studierenden wählen ein Thema und verfassen eine eigenständige Arbeit. Sie werden dabei von ihrer Betreuungsperson begleitet. 

Lecture notes: Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature: Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice: Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.
Subject with an Educational Focus Chemistry A

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content
Thematic Schwerpunkte:

Lernformen:

Lecture notes
Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites /
notice
Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.

Compulsory Elective Courses

see Compulsory Elective Courses Teaching Diploma

Chemistry Teaching Diploma - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
</tbody>
</table>

E- Recommended, not eligible for credits
Z Courses outside the curriculum
Dr Suitable for doctorate

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
</tbody>
</table>

P practical/laboratory course
A independent project
D diploma thesis
R revision course / private study

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Organic Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0233-01L</td>
<td>Organic Synthesis: Methods and Strategies</td>
<td>W+</td>
<td>6 credits</td>
<td>3G</td>
<td>E. M. Carreira</td>
</tr>
</tbody>
</table>

Abstract
The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

Objective

Content

Prerequisites / notice
OC I-IV

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies fostered

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation assessed

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

## Physical Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0433-01L</td>
<td>Advanced Physical Chemistry: Statistical Thermodynamics</td>
<td>W+</td>
<td>6 credits</td>
<td>3G</td>
<td>R. Riek, J. Richardson</td>
</tr>
</tbody>
</table>

Abstract
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.
All technologies used for the experiments will be explained to the students in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.


- Additionally, students can obtain more information by visiting http://www.kast.ethz.ch/teaching.html or contacting P. Kast directly (HCI F 333, Tel. 044 632 29 08, kast@org.chem.ethz.ch).

For more information, see also http://www.kast.ethz.ch/teaching.html or contact P. Kast directly (HCI F 333, Tel. 044 632 29 08, kast@org.chem.ethz.ch).

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**Research Projects**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0200-10L</td>
<td>Research Project I</td>
<td>W</td>
<td>13 credits</td>
<td>16A</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student. Students are accustomed to scientific work and they get to know one specific research field.</td>
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<tr>
<td>529-0201-10L</td>
<td>Research Project II</td>
<td>W</td>
<td>13 credits</td>
<td>16A</td>
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<tr>
<td>Abstract</td>
<td>In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student. Students are accustomed to scientific work and they get to know one specific research field.</td>
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**Industry Internship or Laboratory Course**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0202-10L</td>
<td>Industry Internship</td>
<td>W</td>
<td>13 credits</td>
<td></td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Internship in industry with a minimum duration of 7 weeks</td>
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<tr>
<td>Objective</td>
<td>The aims of the internship is to make students acquainted with industrial work environments. During this time, they will have the opportunity to get involved in current projects of the host institution.</td>
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<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0739-10L</td>
<td>Biological Chemistry A: Technologies for Directed Evolution of Enzymes</td>
<td>W</td>
<td>13 credits</td>
<td>16P</td>
<td>P. A. Kast</td>
</tr>
</tbody>
</table>
| Abstract | Advanced laboratory course or internship depending on lab course Biological Chemistry B Candidates must inquire with P. Kast no later than September 1st whether course will take place (no self-enrollment) During this semester course, methodologies will be taught for biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. All technologies used for the experiments will be explained to the students in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared. This course conducts and supports experiments for a specifically designed genuine research project. We will carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The relevant technologies will be taught to the students, such as the preparation of competent cells, production and isolation of DNA fragments, transformation of gene libraries, and DNA sequencing. The course participants will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The students will present the results obtained from their individual evolution experiments at the end of the semester. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalyst. The necessary documents and protocols will be distributed to the participants during the course. General literature to "Directed Evolution" and chorismate mutases, e.g.: Taylor, S. V., P. Kast & D. Hilvert. 2001. Investigating and engineering enzymes by genetic selection. Angew. Chem. Int. Ed. 40: 3310-3335.


Further literature will be indicated in the distributed script. - This laboratory course will involve experiments that require a tight schedule and (sometimes) long (!) working days. - The projects of this course are tightly linked to the ones of the Biology BSc course "529-0739-01 Biological Chemistry B: New Enzymes from Directed Evolution Experiments", which takes place as a block course during the month of November. There will be joint lectures for the participants of both courses during that time. The teaching language is English.

- The number of participants for the laboratory class is limited. It is mandatory to sign up for the course directly with P. Kast no later than September 1, prior to the start of the fall semester. Until then it will be decided whether the course will take place. - A valid registration is considered a commitment for attendance of the entire semester course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast. - For more information, see also http://www.kast.ethz.ch/teaching.html or contact P. Kast directly (HCI F 333, Tel. 044 632 29 08, kast@org.chem.ethz.ch).
### Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0500-10L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>25</td>
<td>54D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

- Only students who fulfill the following criteria are allowed to begin with their Master's thesis:
  a. successful completion of the Bachelor's programme;
  b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.

*Duration of the Master’s Thesis 20 weeks.*

### Electives

Students are free to choose from a range of D-CHAB chemistry courses appropriate to their level of study (please note admission requirements). In case of doubt, contact the student administration.

### Inorganic Chemistry

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>529-0141-00L</td>
<td>Physical Methods for Inorganic Chemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>M. D. Wörle, D. Günther, J. Koch, R. Verel</td>
</tr>
</tbody>
</table>

- Introduction into the important methods for structural analysis (solid state NMR), crystal structure analysis and surface analysis techniques and their applications
- Knowledge in solid state NMR, crystal structure analysis and surface analytical techniques relevant for inorganic materials
- This lecture course consists of three parts 1) Solid-state NMR 2) Surface and direct solid analysis 3) Crystal structure analysis. Most important fundamentals of the individual methods will be presented and details will be explained on most relevant inorganic applications
- Will be given during the lectures

### Organic Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0243-01L</td>
<td>Transition Metal Catalysis: From Mechanisms to Applications</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>B. Morandi</td>
</tr>
</tbody>
</table>

- Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint
- Understanding and critical evaluation of current research in transition metal catalysis. Design of mechanistic experiments to elucidate reaction mechanisms. Synthetic relevance of transition metal catalysis. Students will also learn about writing an original research proposal during a workshop.
- Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint. Synthetic applications of these reactions. Introduction and application of tools for the elucidation of mechanisms. Selected examples of topics include: C-H activation, C-O activation, C-C activation, redox active ligands, main group redox catalysis, bimetallic catalysis.
- Lecture slides will be provided online. A Handout summarizing important concepts in organometallic and physical organic chemistry will also be provided. Useful references and handouts will also be provided during the workshop.
- Slides will be uploaded 1-2 days before each lecture on http://morandi.ethz.ch/education.html

**Literature**

Primary literature and review articles will be cited during the course.

The following textbooks can provide useful support for the course:


**Prerequisites / notice**

**Required level:** Courses in organic and physical chemistry (kinetics in particular) of the first and second year as well as ACI and III case of doubt, contact the student administration.

**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Adaptable and Flexibility

**E. M. Carreira**

**Abstract**

The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

**Objective**

Extension and deepening of the knowledge in organic synthesis and the principles of structure and reactivity.

**Content**

Literature

Prerequisites / notice
OC I-IV

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Selectivity in Organic Synthesis
W 6 credits 3G J. W. Bode

Abstract
Fundamentals of selective organic reactions, including current and historical examples of enantioselectivity, regioselectivity, chemoselectivity. Further aspects include recent developments in catalysis, strategies and tools for selective organic synthesis.

Objective
Understanding and explaining the origin of selectivity in organic synthesis and the application of selective organic reactions to the construction of complex organic and biological molecules.

Content
Fundamental concepts and recent advances for the selective synthesis of complex organic molecules, including natural products, pharmaceuticals, and biological molecules. Key concepts include the development of enantioselective and regioselective catalysts, the identification of new reaction mechanisms and pathways, and technological advances for facilitating the synthesis of organic molecules. Analysis of key primarily literature including identification of trends, key precendents, and emerging topics will be emphasized.

Lecture notes
will be provided in class and online

Literature
Suggesting Textbooks

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Method-specific Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
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Negotiation assessed

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered

Chemical Biology - Peptides
W 6 credits 3G H. Wennemers

Abstract
An advanced course on the synthesis, properties and function of peptides in chemistry and biology.

Objective
Knowledge of the synthesis, properties and function of peptides in chemistry and biology.

Content
Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.

Lecture notes
Citations from the original literature relevant to the individual lectures will be assigned weekly.

Literature

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Method-specific Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
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Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered

Nucleic Acids and Carbohydrates
W 6 credits 3G K. Lang, M. Frei, P. A. Kast, H. Wennemers

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

Abstract
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 544 of 2667
Content
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA: DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Competencies
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<th>Method-specific Competencies</th>
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<td>Self-awareness and Self-reflection</td>
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<td>Techniques and Technologies</td>
<td>Problem-solving</td>
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<tr>
<td>529-0433-01L</td>
<td>Advanced Physical Chemistry: Statistical Thermodynamics</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>R. Riek, J. Richardson</td>
</tr>
</tbody>
</table>

Abstract
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Objective
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Content

Lecture notes
See homepage of the lecture.

Literature
See homepage of the lecture.

Prerequisites / notice
Chemical Thermodynamics, Reaction Kinetics, Molecular Quantum Mechanics and Spectroscopy; Mathematical Foundations (Analysis, Combinatorial Relations, Integral and Differential Calculus)

Competencies
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</table>

529-0027-00L
Advanced Magnetic Resonance - Solid State NMR

Abstract
The course is for advanced students and introduces and discusses the theoretical foundations of solid-state nuclear magnetic resonance (NMR).

Objective
The aim of the course is to familiarize the students with the basic concepts of modern high-resolution solid-state NMR. Starting from the mathematical description of spin dynamics, important building blocks for multi-dimensional experiments are discussed to allow students a better understanding of modern solid-state NMR experiments. Particular emphasis is given to achieving high spectral resolution.

Content
The basic principles of NMR in solids will be introduced. After the discussion of basic tools to describe NMR experiments, basic methods and experiments will be discussed, e.g., magic-angle spinning, cross polarization, decoupling, and recoupling experiments. Such basic building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

Lecture notes
A script which covers the topics will be distributed in the lecture and will be accessible through the web page http://www.ssnmr.ethz.ch/education/

Prerequisites / notice
Prerequisite: A basic knowledge of NMR, e.g. as covered in the Lecture Physical Chemistry IV, or the book by Malcolm Levitt.

529-0130-00L
Advanced Magnetic Resonance - DNP Instrumentation and Applications

Abstract
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. The following topics will be covered:
- DNP theory & instrumentation
- Microwave theory & technology
- Biological applications of solid-state DNP

Objective
The course aims at enabling students to understand the key theoretical points of DNP and to design DNP experiments. Students will be familiarized with the structure of the state-of-the-art DNP instrumentation. Students will be also informed about the technological challenges towards the development of advanced instrumentation for the future DNP experiments. A special focus will be given in the technology of microwave source.
Furthermore, students will become familiar with pulse sequences used in biomolecular applications and understand how they are constructed. Students will be able to identify the strengths and weaknesses of biomolecular DNP and how to design DNP experiments for biological applications including sample preparation and choice of NMR experiment and related parameters.
Content

The course is separated in three well separated parts.

The first part will cover DNP concept and mechanisms, while a special focus will be given in DNP instrumentation, such as MAS technology, and the NMR probe. Several details will be also presented on the development high field NMR magnet.

The second part of the course is dedicated to the microwave theory and technology. This part starts with an introduction of the two different types of microwave sources, such as the solid-state devices and vacuum tubes, which are extensively used in DNP and EPR spectroscopy. A special focus will be given to the vacuum tube's theory and technology. In this context, the Maxwell equations and the propagation of the transverse electric and transverse magnetic modes in circular waveguides will be taught. This material will be the basis for understanding the resonance theory and the fundamentals of the microwave's generation in vacuum tubes. Based on the theoretical background gained in the previous lectures it will be possible to understand the operation principle of the slow wave devices, such as Klystron, Traveling Wave Tube (TWT), Backward Wave Oscillator (BWO) and Surface Wave Structure (SWS), as well as, the fast wave devices, such as gyro-devices, Free Electron Laser, etc. Finally, some details on the structure of a real DNP gyrotron will be presented.

The third part of the course will cover CPMAS and homonuclear and heteronuclear recoupling schemes and their use in correlation spectroscopy for structure and molecular interaction determination. Sample preparation with particular emphasis of glassing agents and their relationship to DNP enhancements will be discussed. Resolution under DNP including a discussion about inhomogeneous and homogeneous broadening at cryogenic temperatures. Methods for circumventing low resolution at cryogenic temperatures will be discussed including site specific isotope labeling, bio-orthogonal labeling and site specific radical labeling/targeting. Concepts around the role of spin diffusion in DNP, direct and indirect DNP, paramagnetic broadening, longitudinal T1 and methyl quenching in biological NMR will also be discussed. These concepts will then be tied together through discussions of biomolecular applications of solid-state DNP including membrane proteins, in-cell DNP and viruses.

Lecture notes

A script, which covers the topics will be accessible through the course Moodle

Prerequisites / notice

Prerequisite: A basic knowledge of Magnetic Resonance, e.g. as covered in the Lecture Physical Chemistry IV, or the book "Spin Dynamics" by Malcolm Levitt.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tbody>
<tr>
<td>529-0043-01L</td>
<td>Analytical Strategy</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>R. Zenobi, S. Giannoukos, D. Günther</td>
</tr>
</tbody>
</table>

Abstract


Lecture notes

Copies of problem sets and solutions will be distributed free for charge

Prerequisites / notice

529-0051-00 "Analytical Chemistry I (3. Semester)"
529-0058-00 "Analytical Chemistry II (4. Semester)" (or equivalent)
Chemical Aspects of Energy

Number Title Type ECTS Hours Lecturers
151-0209-00L Renewable Energy Technologies W 4 credits 3G A. Bardow, E. Casati

Abstract
The first part of the course covers the engineering aspects of the prominent renewable energy technologies: solar (PV and thermal), wind, hydro, geothermal and bioenergy. We further discuss energy storage, renewable transport and renewable heating & cooling. Finally, we introduce the key concepts of the economics of renewable energy and its integration in the energy system.

Objective
Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Lecture notes
Lecture Notes containing copies of the presented slides.

Prerequisites / notice
Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.
### Chemical Crystallography

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<tbody>
<tr>
<td>529-0029-01L</td>
<td>Structure Determination</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>M. D. Wörle, N. Trapp</td>
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</table>

**Abstract**
Advanced X-ray crystal structure analysis

**Objective**
To gain a deeper understanding of crystal structure determination principles and practice by X-ray diffraction and the evaluation of results.

**Content**
Review of principles of diffraction and instrumentation, unit cells, lattices, and symmetry. Inorganic structural chemistry: sphere packings, ionic crystals, covalent networks, intermetallic compounds. Overview of powder diffraction and application of crystal chemistry for structure analysis of polycrystalline phases. Working safely with X-rays, crystal growth, selection and mounting, data collection strategies, data reduction, corrections for absorption, extinction and Lp, advanced structure solution theory and techniques: Patterson function, heavy atom technique, Fourier methods, direct methods. Structure modeling and refinement, disorder, twinning, false symmetry, interpretation of anisotropic shift parameters. Determination of absolute configuration, interpretation of results and scope of chemically useful information, validation and publication of results, critical evaluation of published crystal structures.

**Lecture notes**
Information and exercise sheets will be distributed in loose form.

**Main references**
(2) J.D. Dunitz, "X-ray Analysis and the Structure of Organic Molecules", 1995, Verlag HCA.

**Additional literature**

**Prerequisites / notice**
Students will conduct the computational exercises and examples of structure solution and refinement on personal computers.

**Prerequisite:** Principles of Crystal Structure Determination (529-0039-00L).

### Chemical Technology

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
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<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4</td>
<td>3V</td>
<td>M. Fussenegger</td>
</tr>
</tbody>
</table>

**Abstract**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objective**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content**

**Lecture notes**
Handout during the course.

### Computational Chemistry

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0003-01L</td>
<td>Advanced Quantum Chemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>M. Reiher, T. Weymuth</td>
</tr>
</tbody>
</table>
Abstract
Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer. Examples are:
* Operators derived from principles of relativistic quantum mechanics
* Relativistic effects + methods of relativistic quantum chemistry
* Open-shell molecules + spin-density functional theory
* New electron-correlation theories

Objective
The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. Examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.

Content
1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein’s special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group

Lecture notes
A set of detailed lecture notes will be provided, which will cover the whole course.

Literature
2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992

Note also the standard textbooks:
A) A. Szabo, N.S. Ostlund, Verlag, Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

Prerequisites / notice
Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered
Self-awareness and Self-reflection fostered

529-0004-01L

Classical Simulation of (Bio)Molecular Systems
W 6 credits 4G P. H. Hünenerger, J. Dolenc, S. Riniker

Abstract
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective
Introduction to classical (atomic) computer simulation of (biomolecular) systems, development of skills to carry out and interpret these simulations.

Content
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature
See: www.csms.ethz.ch/education/CSBMS

Prerequisites / notice
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered

Material Science

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 549 of 2667
**327-0703-00L**  
**Electron Microscopy in Material Science**  
Type: W  
ECTS: 4 credits  
Hours: 2V+2U  
Lecturers: S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze

**Abstract**  
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Objective**  
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Content**  
This course provides a general introduction into electron- and ion-microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, focused ion-beam and atom probe microscopes are presented. Throughout the semester, various applications in materials science, solid state physics, structural biology, structural geology, and structural chemistry will be reported.

**Lecture notes**  
Will be distributed in English

**Literature**  
- Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

**Competencies**  
- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- **Social Competencies**
  - Communication
  - Cooperation and Teamwork
  - Negotiation
- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking

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**402-0468-15L**  
**Nanomaterials for Photonic Devices**  
Type: W  
ECTS: 6 credits  
Hours: 2V+1U  
Lecturers: R. Grange, E. Baillly, R. Chapman, V. Falcone, A. Morandi

**Abstract**  
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, photonic integrated circuits, ordered and disordered structures...). It starts with concepts of light-matter interactions, fabrication and characterization, the description of the properties and the state-of-the-art applications and devices.

**Objective**  
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.

**Content**  
1. Introduction to nanophotonics
2. Wave physics for nanophotonics
3. Characterization of nanomaterials
4. Semiconductors
5. Nonlinear crystals
6. Photonic integrated circuits
7. Optical quantum devices
8. Plasmonics
9. Metasurfaces
10. Graphene & 2D Materials
11. Nanocomposites

**Lecture notes / Literature**  
Slides and book chapter will be available for downloading  
References will be given during the lecture

**Prerequisites / notice**  
Basics of solid-state physics (i.e. energy bands) can help

**Competencies**  
- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
- **Social Competencies**
  - Communication
  - Cooperation and Teamwork
  - Leadership and Responsibility
- **Personal Competencies**
  - Creative Thinking
  - Critical Thinking
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

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**327-2145-00L**  
**Advanced Polymer Synthesis**  
Type: W  
ECTS: 4 credits  
Hours: 3G  
Lecturers: T. L. Choi
Modern polymer synthesis (based on recent development of new organic reactions) is discussed to enable students to develop synthesis schemes for certain target structures. Both chain (ionic, coordination, ROMP, radical, catalyst-transfer) and step-growth polymerizations (transition metal catalysis) including how to achieve living polymerization or improve selectivity will be discussed.

Students should be able to: Identify important polymerization procedures and types of polymerization. Predict activities of monomers based on the chemical structures. Devise synthetic pathways to produce a given polymer structure. Evaluate properties of macromolecules based on structure and synthesis method. Develop synthesis schemes for target structures and discuss potential applications of polymers.

Polymerization is a series of continuous organic transformation and connects small molecules. The course will give an overview of the following important polymerization procedures:

- Modern Step-growth polymerization
- Living Anionic polymerization
- Group transfer polymerization (GTP)
- Controlled cationic polymerization
- Controlled radical polymerization
- Coordination polymerization: Ziegler-Natta and Metallocene catalysts
- Olefin metathesis polymerization: ROMP, ADMET and cyclopolymerization
- Synthesis of conjugated polymers based on transition metal catalysis
- Complex macromolecules including brush and dendronized polymers

Students will learn how to deal with chemical structures and reactivities, and be able to suggest reasonable synthetic pathways to a given polymer structure, like conjugated polymers based on transition metal catalysis or complex macromolecules including brush and dendronized polymers. Aspects like controlling molar masses and structure perfection play a role throughout. The course provides the students with a high-level overview of modern methods of polymer synthesis both in theoretical and practical aspects. It should enable them to develop reasonable synthesis schemes for certain target structures and also to predict the properties of given macromolecules. For all polymers presented, potential or real applications will be discussed.

They will be uploaded on Moodle

Lecture notes

Literature

Prerequisites / notice

Strong background of Organic Chemistry. Any course on Introductory Polymer Chemistry such as "Advanced Building Blocks for Soft Materials" or "Introduction to Macromolecular Chemistry" or equivalent (bachelor level is also sufficient). Please discuss with the lecturer if one is not certain about the prerequisites.

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving

Technological Competencies

- Communication
- Customer Orientation

Creative Thinking

Critical Thinking

Social Competencies

- Integrity and Work Ethics

Personal Competencies

Environmental Chemistry

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<th>Hours</th>
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<td>W</td>
<td>6</td>
<td>3</td>
<td>M. Arand, H. Nägeli</td>
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<tr>
<td>529-0180-00L</td>
<td>Sustainable Chemistry and Chemical Engineering in Industry</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>S. J. Mitchell, C. Brocklehurst, E. Godineau, L. Lovelle Gomez, A. Nanchen, F. Robvieux</td>
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<tr>
<td>363-0389-00L</td>
<td>Technology and Innovation Management</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Brusoni, A. Zeijen</td>
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Environmental basis: basic chemistry, biology and biochemistry

Educational basis: basic chemistry, biology and biochemistry

This course, led by Swiss chemical industry experts, teaches sustainable chemistry and relevant chemical engineering concepts through hands-on problem-solving.

The course will consist of 7 modules in 4 h blocks.

This course focuses on the sources of innovation (with a specific focus on digital technologies), the tools and techniques that organizations deploy to innovate routinely, and the strategic implications of technical change at different levels of analysis: individuals, firms and whole ecosystems.
Objective
This course intends to enable all students to:

- Acquire and understand the basic jargon, concepts and methods necessary to discuss, in a precise and concise manner, innovation processes and their outcomes at different levels of analysis.

- Analyze the differences between individual and organizational decision processes and their innovative outcomes.

- Evaluate critically the potential of different (digital) technologies to impact business organizations.

Content

Organizations and people are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small. How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

Lecture notes
Slides will be available on the Moodle page.

Literature
Readings will be available on the Moodle page.

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics.

Competencies

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363-0565-00L Principles of Macroeconomics

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This course will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course Moodle page contains announcements, course information and lecture slides.

Literature
The set-up of the course will closely follow the book of N. Gregory Mankiw and Mark P. Taylor (2023), Economics, Cengage Learning, 6th Edition. This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Compencies

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Compensatory courses

Inorganic Chemistry
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. The following topics will be will be given during the lectures:

- **Title**: Physical Methods for Inorganic Chemistry
- **Type**: Lecture
- **ECTS**: 6 credits
- **Hours**: 3G
- **Lecturers**: M. D. Wörle, D. Günther, R. Verel

**Abstract**
Introduction into the important methods for structural analysis (solid state NMR), crystal structure analysis and surface analysis techniques and their applications

**Objective**
Knowledge in solid state NMR, crystal structure analysis and surface analytical techniques relevant for inorganic materials

**Content**
This lecture course consists of three parts: 1) Solid-state NMR 2) Surface and direct solid analysis 3) Crystal structure analysis. Most important fundamentals of the individual methods will be presented and details will be explained on most relevant inorganic applications.

**Lecture notes**
A script which covers the topics will be distributed in the lecture and will be accessible through the web page http://www.ssnmr.ethz.ch/education/

**Prerequisites / notice**
Prerequisite: A basic knowledge of NMR, e.g. as covered in the Lecture Physical Chemistry IV, or the book by Malcolm Levitt.

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**Physical Chemistry**

**Number**: 529-0027-00L

**Title**: Advanced Magnetic Resonance - Solid State NMR and Applications

**Type**: Lecture

**ECTS**: 6 credits

**Hours**: 3G

**Lecturers**: M. Ernst

**Abstract**
The course is for advanced students and introduces and discusses the theoretical foundations of solid-state nuclear magnetic resonance (NMR).

**Objective**
The aim of the course is to familiarize the students with the basic concepts of modern high-resolution solid-state NMR. Starting from the mathematical description of spin dynamics, important building blocks for multi-dimensional experiments are discussed to allow students a better understanding of modern solid-state NMR experiments. Particular emphasis is given to achieving high spectral resolution.

**Content**
The basic principles of NMR in solids will be introduced. After the discussion of basic tools to describe NMR experiments, basic methods and experiments will be discussed, e.g., magic-angle spinning, cross polarization, decoupling, and recoupling experiments. Such basic building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

**Lecture notes**
A script which covers the topics will be distributed in the lecture and will be accessible through the web page http://www.ssnmr.ethz.ch/education/

**Prerequisites / notice**
Prerequisite: A basic knowledge of NMR, e.g. as covered in the Lecture Physical Chemistry IV, or the book by Malcolm Levitt.

**Number**: 529-0130-00L

**Title**: Advanced Magnetic Resonance - DNP Instrumentation and Applications

**Type**: Lecture

**ECTS**: 6 credits

**Hours**: 3G

**Lecturers**: A. Barnes

**Abstract**
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. The following topics will be covered:
- DNP theory & instrumentation
- Microwave theory & technology
- Biological applications of solid-state DNP

**Objective**
The course aims at enabling students to understand the key theoretical points of DNP and to design DNP experiments. Students will be familiarized with the structure of the state-of-the-art DNP instrumentation. Students will be also informed about the technological challenges towards the development of advanced instrumentation for the future DNP experiments. A special focus will be given in the technology of microwave source. Furthermore, students will become familiar with pulse sequences used in biomolecular applications and understand how they are constructed. Students will be able to identify the strengths and weaknesses of biomolecular DNP and how to design DNP experiments for biological applications including sample preparation and choice of NMR experiment and related parameters.

**Content**
The course is separated in three well separated parts:

1. The first part will cover DNP concept and mechanisms, while a special focus will be given in DNP instrumentation, such as MAS technology, and the NMR probe. Several details will be also presented on the development high field NMR magnet.

2. The second part of the course is dedicated to the microwave theory and technology. This part starts with an introduction of the two different types of microwave sources, such as the solid-state devices and vacuum tubes, which are extensively used in DNP and EPR spectroscopy. A special focus will be given to the vacuum tube’s theory and technology. In this context, the Maxwell equations and the propagation of the transverse electric and transverse magnetic modes in circular waveguides will be taught. This material will be the basis for understanding the resonance theory and the fundamentals of the microwave’s generation in vacuum tubes. Based on the theoretical background gained in the previous lectures it will be possible to understand the operation principle of the slow wave devices, such as Klystron, Traveling Wave Tube (TWT), Backward Wave Oscillator (BWO) and Surface Wave Structure (SWS), as well as, the fast wave devices, such as gyro-devices, Free Electron Laser, etc. Finally, some details on the structure of a real DNP gyrotron will be presented.

3. The third part of the course will cover CPMAS and homonuclear and heteronuclear recoupling schemes and their use in correlation spectroscopy for structure and molecular interaction determination. Sample preparation with particular emphasis of glassing agents and their relationship to DNP enhancements will be discussed. Resolution under DNP including a discussion about inhomogeneous and homogeneous broadening at cryogenic temperatures.

Methods for circumventing low resolution at cryogenic temperatures will be discussed including site specific isotope labeling, bio-orthogonal labeling and site specific radical labeling/targeting. Concepts around the role of spin diffusion in DNP, direct and indirect DNP, paramagnetic broadening, longitudinal T1 and methyl quenching in biological NMR will also be discussed. These concepts will then be tied together through discussions of biomolecular applications of solid-state DNP including membrane proteins, in-cell DNP and viruses.

**Lecture notes**
A script which covers the topics will be accessible through the course Moodle

**Prerequisites / notice**
Prerequisite: A basic knowledge of Magnetic Resonance, e.g. as covered in the Lecture Physical Chemistry IV, or the book "Spin Dynamics" by Malcolm Levitt.

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**Course Units for Additional Admission Requirements**

The courses below are only available for MSc students with additional admission requirements.

**Number**: 529-0051-AAL

**Title**: Analytical Chemistry I

**Type**: Lecture

**ECTS**: 3 credits

**Hours**: 6R

**Lecturers**: D. Günther, R. Zenobi

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Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

The underlying lecture (529-0051-00L) is offered in autumn semester but only in German.

Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications.

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.
- UV/VIS spectroscopy: Basics, interpretation of electron spectra. Circular dichroism (CD) and optical rotation dispersion (ORD).

Lecture notes
Script will be provided for the production price

Literature
- D. A. Skoog and J. D. Leary. Instrumentelle Analytik, Springer, Heidelberg, 1996;

Prerequisites / notice
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

529-0058-AAL
Analytical Chemistry II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Enhanced knowledge about the elemental analysis and spectroscopical techniques with close relation to practical applications. This course is based on the knowledge from analytical chemistry I. Separation methods are included.

Objective
Use and applications of elemental analysis and spectroscopical knowledge to solve relevant analytical problems.

Content
Combined application of spectroscopic methods for structure determination, and practical application of element analysis. More complex NMR methods: recording techniques, application of exchange phenomena, double resonance, spin-lattice relaxation, nuclear Overhauser effect, applications of experimental 2d and multipulse NMR spectroscopy, shift reagents. Application of chromatographic and electrophoretic separation methods: basics, working technique, quality assessment of a separation method, van-Deemter equation, gas chromatography, liquid chromatography (HPLC, ion chromatography, gel permeation, packing materials, gradient elution, retention index), electrophoresis, electrosomotic flow, zone electrophoresis, capillary electrophoresis, isoelectrical focussing, electrophrochromatography, 2d gel electrophoresis, RDS-resolution, field flow fractionation, enhanced knowledge in atomic absorption spectroscopy, atomic emission spectroscopy, X-ray fluorescence spectroscopy, ICP-OES, ICP-MS.

Literature
- D. A. Skoog and J. D. Leary. Instrumentelle Analytik, Springer, Heidelberg, 1996;
- F. Foret, L. Krivankova, and P. Bocek. Capillary Zone Electrophoresis, VCH, Weinheim (1993);

Prerequisites / notice
None.

529-0132-AAL
Inorganic Chemistry III: Organometallic Chemistry and E-Homogeneous Catalysis

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbynylation, C=C bond-forming and related reactions.

Objective
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

Content
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbynylation, C=C bond-forming and related reactions.
This course does not offer a lecture of its own but it is linked to the course 529-0431-00L.

### Literature


### Competencies

Subject-specific Competencies
- Concepts and Theories: assessed

Method-specific Competencies
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

### 529-0431-AAL

**Physical Chemistry III: Molecular Quantum Mechanics**

- **Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**
- **4 credits**
- **9R**
- **F. Merkt**

This course does not offer a lecture of its own but it is linked to the course 529-0431-00L.

### Abstract

Postulates of quantum mechanics, operator algebra, Schrödinger’s equation, state functions and expectation values, matrix representation of operators, particle in a box, tunneling, harmonic oscillator, molecular vibrations, angular momentum and spin, generalised Pauli principle, perturbation theory, electronic structure of atoms and molecules, Born-Oppenheimer approximation.

### Objective

This is an introductory course in quantum mechanics. The course starts with an overview of the fundamental concepts of quantum mechanics and introduces the mathematical formalism. The postulates and theorems of quantum mechanics are discussed in the context of experimental and numerical determination of physical quantities. The course develops the tools necessary for the understanding and calculation of elementary quantum phenomena in atoms and molecules.

### Content

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

#### Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

### Chemistry Master - Key for Type

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<tr>
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<th>Description</th>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

### ECTS

ECTS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.

Specific topics covered in the course include, but are not limited to:

1. **Theoretical Concepts**
   - Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. **Microfluidic Device Manufacture**
   - Basic principles of conventional lithography of rigid materials, 'soft' lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. **Electrokinetics**
   - Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. **Mass Transfer Phenomena**
   - Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. **Heat Transfer Phenomena**
   - Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. **Microfluidic Systems for Materials Synthesis**
   - Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. **Point-of-Care Diagnostics**
   - Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. **Microscale DNA Amplification**
   - Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. **Small volume Molecular Detection**
   - Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. **Droplets and Segmented Flows**
    - Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. **Single Cell Analysis**
    - Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

### Lecture notes
Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

### Literature
There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

### Competencies
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: assessed
- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed
- **Personal Competencies**
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed

### Number 529-0615-01L

**Biochemical and Polymer Reaction Engineering**

- **Type**: W+ 6 credits
- **ECTS**: 3G
- **Lecturers**: P. Arosio, P. Fleckenstein

**Abstract**


**Objective**

The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.
Products and Materials

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0619-01L</td>
<td>Chemical Product Design</td>
<td>W+</td>
<td>6 credits</td>
<td>3G</td>
<td>W. J. Stark</td>
</tr>
</tbody>
</table>

Abstract
The 'Chemical Product Design' course teaches students quantitative concepts to analyze, select and transform theoretical concepts from chemistry and engineering into valuable real-world products. Basic chemistry and chemical engineering knowledge is required (Diffusion, Thermodynamics, Kinetics, ...).

Objective
This course starts with analyzing existing chemical needs and unmet technical challenges. We then develop the skills to critically analyze a specific chemical idea for a product, to rapidly test feasibility or chance for success and to eventually realize its manufacturing. The chemical engineering basics are then used to assess performance of products or devices with non-traditional functions based on dynamic properties (e.g., responsive building materials, personal medical diagnostics on paper strips). The course teaches the interface between laboratory and market with a specific focus on evaluating the chemical value of a given process or product, and the necessary steps to pursue the resulting project within an entrepreneurial environment. We therefore extend the questions of process design ('how do we make something?') to the question of 'what should we make?'

Content

Part A: The 'Chemical Product Design' course starts with discussing questions along, 'What is a chemical product, and why do people pay for it? How does a given compound in a specific context provide a service? We then learn how to translate new, often ill-defined wishes or ideas into quantifiable specifications.

Part B: Thermodynamic and kinetic data allow sharp selection criteria for successful products. We learn how to deal with insufficient data and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation units as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value generated.

Students are expected to actively develop chemical products along the course during the exercise sessions. Contributions will be made in small groups, where a larger topic is studied. The progress of each group will be followed by reports and short presentations during the semester, and one final pitching presentation at the end of the semester. Active participation in the group projects is mandatory for the admission to the oral exam.

Literature


Prerequisites / Competencies
Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics, ...). Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, fostered, fostered.
Main books

Other references

Prerequisites / notice
A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

529-0613-01L Process Simulation and Flowsheeting W+ 6 credits 3G G. Guillén Gosálbez

Abstract
This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies. Commercial software packages (Aspen) are introduced for solving process flowsheeting and optimization problems.

Objective
This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

Content
Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process flowsheeting:
- Flowsheet partitioning and tearing
- Solution methods for process flowsheeting
- Simultaneous methods
- Sequential methods

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
- Non-linear programming, NLP
- Mixed-integer linear programming, MILP
- Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimisation & debugging

An exemplary literature list is provided below:

Prerequisites / notice
Module "Process Simulation and Flowsheeting" before "Process Design and Development", but it is not mandatory.

Catalysis and Separation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-0927-00L</td>
<td>Rate-Controlled Separations in Fine Chemistry</td>
<td>W+</td>
<td>6</td>
<td>3V+1U</td>
<td>M. Mazzaoti, V. Becattini, N. Casas, F. Kiefer</td>
</tr>
</tbody>
</table>

Abstract
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.
Objective: The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

Content: The class covers separation techniques that are central in the purification and downstream processing of chemicals and biopharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

Lecture notes: Handouts during the class

Literature: Recommendations for textbooks will be covered in the class

Prerequisites / notice: Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)

Competencies:

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

529-0617-01L Catalysis Engineering

W+ 6 credits 3G J. Pérez-Ramírez, S. J. Mitchell

Abstract: Heterogeneous catalysis, an enabling foundation of the chemical industry, spearheads innovation toward key sustainability targets in clean energy, carbon neutrality, and zero waste. The Catalysis Engineering course provides students with concepts bridging from the molecular-level design of catalytic materials to their technical application.

Objective: To accelerate the discovery and implementation of sustainable technologies, this vibrant discipline is constantly refining its design principles, particularly at the nanoscale, a shift facilitated by the availability of increasingly powerful tools that permit the continued development of fundamental knowledge over different time and length scales. During this course, you will learn current concepts for the defossilization of the chemical industry and strategies for achieving this goal from idea to implementation. By introducing topical case studies both in lectures and through a semester project, you will see aspects of catalyst synthesis and characterization, kinetics, mass and heat transport, deactivation and process design, sustainability metrics, and the potential of digital tools to guide catalyst design. Since this area is rapidly advancing and no textbooks are available, the lectures follow slides and journal articles.

Content: The aspects described above will be demonstrated through industrially-relevant examples such as:
- Natural gas valorization
- CO2 conversion to energy vectors
- Plastics upcycling
- Concept for a glycerol biorefinery
- Halogen chemistry on catalytic surfaces
- Ensemble design for selective hydrogenations
- Single-atom catalysis
- Hierarchical zeolite catalysts

A supervised semester project conducted in small groups provides a taste of catalysis research on a timely topic. Students will learn basic skills including critical literature analysis, problem definition and solving, methods of catalyst synthesis, characterization, and testing, and data evaluation and communication through a short talk.

Lecture notes: The course material is based on slides and journal articles.

Prerequisites / notice: It is assumed that students selecting this course are familiar with basic concepts of chemistry and catalysis (chemistry or chemical engineering background). Other students are welcome to contact us to discuss the requirement for prior knowledge.

Case Study

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract: The learning objective is to design, simulate and optimize a real (bio-)chemical process from a process systems perspective. Specifically, a commercial process simulation software (Aspen) will be used for the process simulation and optimization. Students have to integrate knowledge and develop engineering thinking and skills acquired in the other courses of the curriculum.

Objective: Simulate and optimize a chemical production process using commercial process simulation software.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 560 of 2667
The aim of the internship is to make students acquainted with industrial work environments. During this time, they will have the opportunity to gain admission to the Master's programme.

Evaluate the performance of the production process.
- Students will analyse and understand the degrees of freedom in modelling process units and flowsheets.
- Students will understand the role of process simulators in process creation.
- Students will make design specifications and follow the iterations implemented to satisfy them.
- Students will judge the role of process simulators in equipment sizing and costing and profitability analysis.
- Students will assess the economic performance of the process, including operating costs (OPEX), and capital investment (CAPEX), based on the outcome of the simulation model.
- Students will assess the environmental impact of the production process following the Life Cycle Assessment (LCA) methodology.

Optimize the design and operating conditions of the production process.
- Students will carry out sensitivity analyses and optimizations considering technical and economic criteria.
- Students will generate process integration alternatives to improve the initial design.
- Students will optimize the production process considering economic and environmental criteria.

Before the case study week, students are encouraged to participate in the exercises of the course "Process Simulation and Flowsheeting" in order to get familiar with the Aspen Plus simulation software (this is highly recommended, but not mandatory).

The problem statement and detailed instructions are provided in the project brief made available at the beginning of the case study week.

During the case study week:
- Students work in teams of 4-6 people.
- Students have to pose and solve process equipment and system design related problems.
- Students have to coordinate the activities, the preparation of the written report and the oral presentation.
- Students get support from project assistants and the course supervisor.

The groups deliver the written report on a predefined date.

The students receive the feedback and are asked to implement some changes in their reports.

A final presentation takes place summarizing the main findings of the project.

### Research Project or Industry Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<td>529-0300-10L</td>
<td>Research Project</td>
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<td>13</td>
<td>16A</td>
<td>Supervisors</td>
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<tr>
<td>Abstract</td>
<td>In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.</td>
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<tr>
<td>Objective</td>
<td>First contact with experimental techniques of chemical engineering in a research group. Critical evaluation and presentation of the results in a scientific report.</td>
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<tr>
<td>Content</td>
<td>This laboratory project is organised during the spring vacation before the sixth semester. The participant can choose his topic from the list of projects suggested. Main emphasis during this research work is to get experience in using different engineering tools and evaluation and the interpretation of the results. Those are presented as a scientific report.</td>
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<td>529-0301-00L</td>
<td>Internship in industry with a minimum duration of 7 weeks</td>
<td>W</td>
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<tr>
<td>Abstract</td>
<td>The aim of the internship is to make students acquainted with industrial work environments. During this time, they will have the opportunity to get involved in current projects of the host institution.</td>
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<tr>
<td>Objective</td>
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### Master's Thesis

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<th>Supervisors</th>
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<tbody>
<tr>
<td>529-0600-10L</td>
<td>Only students who fulfill the following criteria are allowed to begin with their Master's thesis: a. successful completion of the Bachelor's programme; b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.</td>
<td>O</td>
<td>25</td>
<td>54D</td>
<td>Supervisors</td>
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<tr>
<td>Abstract</td>
<td>Duration of the Master's Thesis 20 weeks.</td>
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<tr>
<td>Objective</td>
<td>In the Master's thesis students prove their ability to independent, structured and scientific working. The Master's thesis is usually carried out in a core or optional subject area as chosen by the student.</td>
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### Electives

#### Biochemical Engineering

<table>
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<tr>
<th>Number</th>
<th>Biological Engineering and Biotechnology</th>
<th>W</th>
<th>4</th>
<th>3V</th>
<th>M. Fussenegger</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
<td></td>
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<td>Objective</td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
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</table>
### Computational Systems Biology

**Abstract**
Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

**Objective**
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

**Content**
Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

**Lecture notes**
http://www.csb.ethz.ch/education/lectures.html

**Literature**


### Biocompatible Materials

**Abstract**
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**
Handouts are deposited online (moodle).

**Literature**


(available online via ETH library)

Handouts and references therein.

### Biochemical and Polymer Reaction Engineering

**Abstract**

**Objective**
The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

**Content**
We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes, Kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

**Lecture notes**
Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html

**Literature**

### Biomicrofluidic Engineering

**Abstract**
Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.
Objective

We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.

Content

Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, 'soft' lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small volume Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. Single Cell Analysis
    Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

Lecture notes

Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

Literature

There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Techniques and Technologies
- assessed
- assessed
- assessed
- assessed
- assessed
- assessed
- assessed

Method-specific Competencies

- Communication
- Cooperation and Teamwork
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- assessed
- assessed
- assessed
- assessed

Social Competencies

- assessed

Personal Competencies

- assessed

551-0357-00L Cellular Matters: Properties, Functions and Applications of Biomolecular Condensates

The number of participants is limited to 30 and will only take place with a minimum of 6 participants.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Abstract

This Master level course delves into the emerging field of biomolecular condensates - membrane-less organelles in cells. Using interdisciplinary concepts from biology, chemistry, biophysics, and soft matter, we will explore the biological properties of these condensates, their functions in health and disease, and their potential as new biomimetic materials for various applications.
In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similar to emulsions.

This interdisciplinary course encompasses milestone works and cutting-edge research questions in the young field of biomolecular condensates, including their properties, functions, and applications. The course begins with a lecture series that introduces the topic of condensates to an interdisciplinary audience and provides a theoretical foundation for understanding current research questions in the field. The lecturer provides a base for student presentations of recent publications in the field, and for research seminars given by course lecturers, who are all active researchers with diverse expertise. Through this exciting interdisciplinary understanding of biomolecular condensates, bridging biology, chemistry, biophysics, and soft matter.

Students will not only learn how to critically read and evaluate scientific literature but will also gain valuable experience in giving scientific presentations to an interdisciplinary audience. Each presentation will require an introduction, critical analysis of the results, and a discussion of their significance, allowing student to substantiate their statements with a critical mindset that considers the pros and cons of chosen approaches and methods, as well as any limitations or possible follow-up experiments. This process will enable student to ask relevant question and actively participate in class discussions, further enhancing their scientific skills.

In preparing the presentations, the students will have the unique opportunity to interact closely with each other and with the lecturers, who are all internationally well-established experts, and receive guidance in selecting a topic for the final presentation and supporting literature.

This course is divided into two parts. The first part will introduce the basic concepts essential to the study of biomolecular condensates and phase separation. Topics include: fundamental units and scales in soft matter, phase transitions in biology, biopolymers and molecular self-assembly, introduction to active matter. This will establish a foundation for the second part, which will explore milestone works and current research in the field of biomolecular condensates. Each lecture of this second part will consist of:
1) a short literature seminar, where student groups will present and discuss a milestone paper assigned in advance and
2) a research seminar, where one of the course lecturers will present their own state-of-the-art research in the field, building upon the milestone literature.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Lecture notes: Lecture slides and some scripts will be provided.

Literature: No compulsory textbooks. Literature will be provided during the course.

Com petencies:

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>fostered</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>fostered</td>
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<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
<td>fostered</td>
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<tr>
<th>Method-specific Competencies</th>
<th>Communication</th>
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<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Customer Orientation</td>
<td>fostered</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<tr>
<th>Social Competencies</th>
<th>Adaptability and Flexibility</th>
<th>fostered</th>
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<tbody>
<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
<td>Self-direction and Self-management</td>
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<tr>
<th>Personal Competencies</th>
<th>Critical Thinking</th>
<th>assessed</th>
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<tr>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
<td>Self-direction and Self-management</td>
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**Environment and Energy**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0209-00L</td>
<td>Renewable Energy Technologies</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Bardow, E. Casati</td>
</tr>
</tbody>
</table>

Objective: Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Prerequisites / notice: Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

Lecture notes: Lecture Notes containing copies of the presented slides.

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0659-00L</td>
<td>Electrochemistry: Fundamentals, Cells &amp; Applications</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>L. Gubler</td>
</tr>
</tbody>
</table>

Abstract: Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics & kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion.
Objective
The course establishes the fundamentals to understand and describe electrochemical reactions and phenomena related to these. The students are familiarized with key concepts and approaches in electrochemistry and selected aspects of materials science and engineering and how they are put to use in selected applications.

Content
- Introduction: important quantities & units, terminology;
- Chapter I - Redox reactions, Faraday’s laws;
- Chapter II - Equilibrium electrochemistry: cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces: electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes: conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry: overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry: electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion: important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors: potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion: corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

Lecture notes
lecture notes, lecture slides, exercise & solutions (PDF files)

Literature

Prerequisites / notice
Students should be familiar with the fundamentals of physical chemistry.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Problem-solving: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

529-0745-01L General and Environmental Toxicology W 6 credits 3V M. Arand, H. Nägeli
Abstract
Toxicokinetic and toxicodynamic aspects of xenobiotic interactions with cellular structures and mechanisms. Toxic responses at the level of organs (immune-, neuro-, reproductive and genotoxicity) and organisms. Introduction into developmental toxicology and ecotoxicology.

Objective
Understanding of the impact of chemicals on biological systems; evaluation of the effects from different biomedical perspectives.

Content
Explanation of important interactions between xenobiotic chemicals and cellular structures such as membranes, enzymes, and nucleic acids. Relevance of intake, distribution, excretion, and biochemical transformation processes. Relevance of mixtures. Explanation of important modes of toxic action such as immuno toxicity, neurotoxicity, reproduction toxicity, genotoxicity based on examples of certain xenobiotics and their effects on important organs.

Lecture notes
Course material will be handed out as the lectures progress

Literature
Textbooks of pharmacology and toxicology (cf. list in course material)

Prerequisites / notice
Educational basis: basic chemistry, biology and biochemistry

529-0180-00L Sustainable Chemistry and Chemical Engineering in Industry W 2 credits 2G S. J. Mitchell, C. Brocklehurst, E. Godineau, L. Lovelle Gomez, A. Nanchen, F. Robvieux
Abstract
This course, led by Swiss chemical industry experts, teaches sustainable chemistry and relevant chemical engineering concepts through hands-on problem-solving. The course will consist of 7 modules in 4 h blocks.

Objective
Students gain a deeper understanding of industry challenges and learn to work towards sustainable solutions.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 565 of 2667
Content
1) Safety and Health and their importance for sustainability
2) Green metrics: real-life tools
3) The proper choice of technology and their impact
4) Case Study from fragrance industry
5) Case Study from agrochemical industry
6) Case Study from pharmaceutical industry
7) Case Study from the bulk chemical industry

Lecture notes 
Course notes based on slides

★★ Systems and Process Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0109-00L</td>
<td>Turbulent Flows</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>P. Jenny</td>
</tr>
<tr>
<td>Abstract</td>
<td>Laminar and turbulent flows, instability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scaling - Homogeneous isotropic turbulence, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows</td>
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<tr>
<td>Objective</td>
<td>Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes are available</td>
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★★ Modeling and Simulations

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0611-01L</td>
<td>Molecular Aspects of Catalysts and Surfaces</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>J. A. van Bokhoven, D. Ferri</td>
</tr>
<tr>
<td>Abstract</td>
<td>Basic elements of surface science important for materials and catalysis research. Physical and chemical methods important for research in surface science, material science and catalysis are considered and their application is demonstrated on practical examples.</td>
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<tr>
<td>Objective</td>
<td>Basic aspects of surface science. Understanding of principles of most important experimental methods used in research concerned with surface science, material science and catalysis.</td>
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<tr>
<td>Content</td>
<td>Methods which are covered embrace: Gas adsorption and surface area analysis, IR-Spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, X-ray absorption, solid state NMR, Electron Microscopy and others.</td>
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<tr>
<td>Lecture notes</td>
<td>The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).</td>
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<tr>
<td>Literature</td>
<td>See: <a href="http://www.csms.ethz.ch/education/CSBMS">www.csms.ethz.ch/education/CSBMS</a></td>
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<tr>
<td>Prerequisites</td>
<td>Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).</td>
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For more information about the lecture: www.csms.ethz.ch/education/CSBMS

Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
- Personal Competencies
  - Adaptability and Flexibility: fostered
  - Creative Thinking: fostered

★★ Economics and Technology Management

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0389-00L</td>
<td>Technology and Innovation Management</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Brusoni, A. Zeijen</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course focuses on the sources of innovation (with a specific focus on digital technologies), the tools and techniques that organizations deploy to innovate routinely, and the strategic implications of technical change at different levels of analysis: individuals, firms and whole ecosystems.</td>
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<tr>
<td>Objective</td>
<td>This course intends to enable all students to:</td>
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<td></td>
<td>- Acquire and understand the basic jargon, concepts and methods necessary to discuss, in a precise and concise manner, innovation processes and their outcomes at different levels of analysis</td>
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<td>- Analyze the differences between individual and organizational decision processes and their innovative outcomes</td>
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<td>- Evaluate critically the potential of different (digital) technologies to impact business organizations.</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 566 of 2667
Organizations and people are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small. How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

The course content and methods are designed for students with some background in management and/or economics. Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

The course content and methods are designed for students with some background in management and/or economics.

The course Moodle page contains announcements, course information and lecture slides. This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).
Objective

This course starts with analyzing existing chemical needs and unmet technical challenges. We then develop the skills to critically analyze a specific chemical idea for a product, to rapidly test feasibility or chance for success and to eventually realize its manufacturing. The chemical engineering basics are then used to assess performance of products or devices with non-traditional functions based on dynamic properties (e.g. responsive building materials, personal medical diagnostics on paper strips). The course teaches the interface between laboratory and market with a specific focus on evaluating the chemical value of a given process or compound, and the necessary steps to pursue the resulting project within an entrepreneurial environment. We therefore extend the questions of process design ("how do we make something?") to the question of 'what should we make?'

Content

Part A: The ‘Chemical Product Design’ course starts with discussing questions along, 'What is a chemical product, and why do people pay for it? How does a given compound in a specific setting provide a service?' We then learn how to translate new, often ill-defined wishes or ideas into quantifiable specifications.

Part B: Thermodynamic and kinetic data allow sharp selection criteria for successful products. We learn how to deal with insufficient data and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation units as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value generated.

Students are expected to actively develop chemical products along the course during the exercise sessions. Contributions will be made in small groups, where a larger topic is studied. The progress of each group will be followed by reports and short presentations during the semester, and one final pitching presentation at the end of the semester. Active participation in the group projects is mandatory for the admission to the oral exam.

Literature


Prerequisites / notice

Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...).

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Fostered</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Advanced Polymer Synthesis</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
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<td>T. L. Choi</td>
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</table>

Abstract

Modern polymer synthesis (based on recent development of new organic reactions) is discussed to enable students to develop synthesis schemes for certain target structures. Both chain (ionic, coordination, ROMP, radical, catalyst-transfer) and step-growth polymerizations (transition metal catalysis) including how to achieve living polymerization or improve selectivity will be discussed.

Objective

Students should be able to: Identify important polymerization procedures and types of polymerization. Predict reactivities of monomers based on the chemical structures. Devise synthetic pathways to produce a given polymer structure. Evaluate properties of macromolecules based on structure and synthesis method. Develop synthesis schemes for target structures and discuss potential applications of polymers.

Content

Polymerization is a series of continuous organic transformation and connects small molecules. The course will provide an overview of the following important polymerization procedures:

- Modern Step-growth polymerization
- Living Anionic polymerization
- Group transfer polymerization (GTP)
- Controlled cationic polymerization
- Controlled radical polymerization
- Coordination polymerization: Ziegler-Natta and Metalloene catalysts
- Olefin metathesis polymerization: ROMP, ADMET and cyclopolymerization
- Synthesis of conjugated polymers based on transition metal catalysis
- Complex macromolecules including brush and dendronized polymers

Students will learn how to deal with chemical structures and reactivities, and be able to suggest reasonable synthetic pathways to a given polymer structure, like conjugated polymers based on transition metal catalysis or complex macromolecules including brush and dendronized polymers. Aspects like controlling molar masses and structure perfection play a role throughout. The course provides the students with a high-level overview of modern methods of polymer synthesis both in theoretical and practical aspects. It should enable them to develop reasonable synthesis schemes for certain target structures and also to predict the properties of given macromolecules. For all polymers presented, potential or real applications will be discussed.

Lecture notes

They will be uploaded on Moodle

Literature

Lecture notes will be given


Prerequisites / notice

Strong basic knowledge of Organic Chemistry. Any course on Introductory Polymer Chemistry such as "Advanced Building Blocks for Soft Materials" or "Introduction to Macromolecular Chemistry" or equivalent (bachelor level is also sufficient). Please discuss with the lecturer if one is not certain about the prerequisites.

Competencies

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Process Design

Number | Title                  | Type | ECTS | Hours | Lecturers |
-------|------------------------|------|------|-------|-----------|
529-0643-01L | Process Design and Development | W    | 6    | 3G    | G. Guillén Gosálbez |

Abstract

The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

Objective

The course is focused on the design of Chemical Processes, with emphasis on the preliminary stage of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.
Course: Process Simulation and Flowsheeting

**Content**

Process creation: heuristics vs. mathematical programming.

- Heuristics for reaction and separation operations, heat transfer and pressure change.
- Introduction to optimization in process engineering and the modeling software GAMS.
- Process economic evaluation: equipment sizing and costing, time value of money, cash flow calculations.
- Process environmental evaluation: Life Cycle Assessment (LCA).
- Process integration: sequencing of distillation columns using mixed-integer linear programming (MILP), and synthesis of heat exchanger networks using mixed-integer nonlinear programming (MINLP).
- Batch processes: scheduling, sizing, and inventories.
- Principles of molecular design using mixed-integer programming.

**Lecture notes**

- No script

**Literature**

**Main books**

- Process Simulation and Flowsheeting

**Other references**


**Prerequisites / notice**

- Prerequisite: Basic knowledge on unit operations, mainly reaction engineering and distillation. It is recommended that the student takes the module "Process Simulation and Flowsheeting" before "Process Design and Development", but it is not mandatory.

**529-0613-01L Process Simulation and Flowsheeting**

**Objective**

This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization.

- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

**Content**

- Overview of process simulation and flowsheeting:
  - Definition and fundamentals
  - Fields of application
  - Case studies
- Process simulation:
  - Modeling strategies of process systems
  - Mass and energy balances and degrees of freedom of process units and process systems
- Process flowsheeting:
  - Flowsheet partitioning and tearing
  - Solution methods for process flowsheeting
  - Simultaneous methods
  - Sequential methods
- Process optimization and analysis:
  - Classification of optimization problems
  - Linear programming, LP
  - Non-linear programming, NLP
  - Mixed-integer linear programming, MILP
  - Mixed-integer nonlinear programming, MINLP
- Commercial software for simulation (Aspen Plus):
  - Thermodynamic property methods
  - Reaction and reactors
  - Separation / columns
  - Convergence, optimisation & debugging

**Literature**

- An exemplary literature list is provided below:
  - Smith, R. Chemical process design and integration, Wiley (2005).

**Module Information**

- 6 credits
- 3G
- Autumn Semester 2024
## Catalysis and Separation

### Number Title Type ECTS Hours Lecturers
151-0927-00L Rate-Controlled Separations in Fine Chemistry W 6 credits 3V+1U M. Mazzotti, V. Becattini, N. Casas, F. Kiefer

### Abstract
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

### Objective
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

### Content
The class covers separation techniques that are central in the purification and downstream processing of chemicals and biopharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

### Lecture Notes
Handouts during the class

### Literature
Recommendations for textbook will be covered in the class

### Prerequisites / Notice
Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories assessed</td>
<td>Analytical Competencies assessed</td>
<td>Communication assessed</td>
<td>Adaptability and Flexibility fostered</td>
</tr>
<tr>
<td>Techniques and Technologies assessed</td>
<td>Decision-making fostered</td>
<td>Cooperation and Teamwork fostered</td>
<td>Creative Thinking fostered</td>
</tr>
<tr>
<td>Decision-making fostered</td>
<td>Media and Digital Technologies fostered</td>
<td>Customer Orientation fostered</td>
<td>Critical Thinking assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies fostered</td>
<td>Problem-solving assed</td>
<td>Leadership and Responsibility fostered</td>
<td>Integrity and Work Ethics fostered</td>
</tr>
<tr>
<td>Problem-solving assed</td>
<td>Project Management fostered</td>
<td>Self-presentation and Social Influence fostered</td>
<td>Self-awareness and Self-reflection fostered</td>
</tr>
<tr>
<td>Project Management fostered</td>
<td>Sensitivity to Diversity fostered</td>
<td>Negotiation fostered</td>
<td>Self-direction and Self-management fostered</td>
</tr>
</tbody>
</table>

### Prerequisites / Notice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0617-01L</td>
<td>Catalysis Engineering</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>J. Pérez-Ramírez, S. J. Mitchell</td>
</tr>
</tbody>
</table>

### Abstract
Heterogeneous catalysis, an enabling foundation of the chemical industry, spearheads innovation toward key sustainability targets in clean energy, carbon neutrality, and zero waste. The Catalysis Engineering course provides students with concepts bridging from the molecular-level design of catalytic materials to their technical application.

### Objective
To accelerate the discovery and implementation of sustainable technologies, this vibrant discipline is constantly refining its design principles, particularly at the nanoscale, a shift facilitated by the availability of increasingly powerful tools that permit the continued development of fundamental knowledge over different time and length scales. During this course, you will learn current concepts for the defossilization of the chemical industry and strategies for achieving this goal from idea to implementation. By introducing topical case studies both in lectures and through a semester project, you will see aspects of catalyst synthesis and characterization, kinetics, mass and heat transport, deactivation and process design, sustainability metrics, and the potential of digital tools to guide catalyst design. Since this area is rapidly advancing and no textbooks are available, the lectures follow slides and journal articles.

### Content
The aspects described above will be demonstrated through industrially-relevant examples such as:
- Natural gas valorization
- CO2 conversion to energy vectors
- Plastics upcycling
- Concept for a glycerol biorefinery
- Halogen chemistry on catalytic surfaces
- Ensemble design for selective hydrogenations
- Single-atom catalysis
- Hierarchical zeolite catalysts

A supervised semester project conducted in small groups provides a taste of catalysis research on a timely topic. Students will learn basic skills including critical literature analysis, problem definition and solving, methods of catalyst synthesis, characterization, and testing, and data evaluation and communication through a short talk.

### Lecture Notes
The course material is based on slides and journal articles.

### Prerequisites / Notice
It is assumed that students selecting this course are familiar with basic concepts of chemistry and catalysis (chemistry or chemical engineering background). Other students are welcome to contact us to discuss the requirement for prior knowledge.

## Science in Perspective

### Recommended Science in Perspective (Type B) for CHAB

### Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>529-0051-AAL</td>
<td>Analytical Chemistry I</td>
<td>E-</td>
<td>3 credits</td>
<td>6R</td>
<td>D. Günther, R. Zenobi</td>
</tr>
</tbody>
</table>

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Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

The underlying lecture (529-0051-00L) is offered in autumn semester but only in German.

Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

Lecture notes
Script will be provided for the production price

Literature

Prerequisites / notice
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

Chemical and Bioengineering Master - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium | | |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Chemical Engineering Bachelor

## 1. Semester

### Compulsory Subjects First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0011-02L</td>
<td>General Chemistry (Inorganic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Togni</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
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<td></td>
</tr>
<tr>
<td>Content</td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium constants, acidities, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.</td>
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</table>

<table>
<thead>
<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0011-03L</td>
<td>General Chemistry (Organic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Chen</td>
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<tr>
<td>Abstract</td>
<td>Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions.</td>
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<tr>
<td>Lecture notes</td>
<td>Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt</td>
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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0011-01L</td>
<td>General Chemistry (Physical Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>H. J. Wörner</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.</td>
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</tr>
<tr>
<td>Objective</td>
<td>After the lecture, students will be able to, - to calculate physical quantities and their units which are important for chemistry, - name some properties of chemically relevant particles and propose experimental methods to determine these properties, - name applications and hazards of radioactivity, - categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them, - describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection, - to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them, - analyze and calculate absorption and emission spectra of single-electron atoms, - to set up the Schrödinger equation for a molecular multi-particle system, - independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems, - model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model, - explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom, - explain the structure of the periodic table of elements with the help of the orbital concept, - recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and - establish term symbols for atomic ground states.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.</td>
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<tr>
<td>Lecture notes</td>
<td>See homepage of the lecture.</td>
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<td>Literature</td>
<td>See homepage of the lecture.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Voraussetzungen: Maturastoff. Insbesondere Integral- und Differenzialrechnung.</td>
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<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>fostered</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

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The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, 
fostered

Creative Thinking

Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids)

D. Dirin, T. Segawa, 

P. H. Hünenberger

Concepts and Theories

Introduction to Computer Science

Title

assessed

See: www.csms.ethz.ch/education/InfoI

fostered

Critical Thinking

Mathematical Foundations I: Analysis A

Abstract

Introduction to calculus in one dimension. Building simple models and analysing them mathematically. Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

Objective

Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

Content

Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

Literature

G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag

R. Sperb/M. Akveld: Analysis I (vdf)

L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg

further reading suggestions will be indicated during the lecture

Compe
dencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

assessed

Method-specific Competencies

Problem-solving

assessed

Personal Competencies

Critical Thinking

fostered

fostered

fostered

529-0001-00L

Introduction to Computer Science

Abstract

Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.

Objective

Acquire a starting package concerning the computational aspects of natural sciences; discuss fundamentals of computer architecture, languages, algorithms and programming with an eye to their application in the area of chemistry, biology and material science.

Content

Lecture: Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation; Exercises: Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

Lecture notes

Script booklet (copies of powerpoint slides, in English), distributed at first or second lecture.

Literature

See: www.csms.ethz.ch/education/Infol

Prerequisites / notice

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the written exam, the results of the exercises are taken into account when evaluating the results of the exam (compulsory performance component, 12% of the exam mark; in case of repetition of the exam, the exercise marks from a previous semester can be kept).

For more information about the lecture: www.csms.ethz.ch/education/Infol

Laboratory Courses

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
529-0011-04L | Practical Course General Chemistry | O | 8 credits | 12P | M. Bezdek, D. Dirin, T. Segawa, A. Yakimov

Information about the practical course will be given on the first day.

Abstract

The general chemistry practical course aims at preparing the students for the work in modern chemistry laboratory. The students are trained to behave safely in the laboratory and use chemicals, chemistry glassware, and related equipment to perform and analyze the equilibrium in basic chemical reactions.

Objective

The students are expected to gain practical experience with as well as establish understanding of the following concepts and phenomena:

- Safe behavior and safety regulations in chemistry laboratory;

- Best practices in common techniques (purification, recrystallization, distillation, etc.);

- Analysis of measured values (measuring error, average value, error analysis);

- Acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems);

- Precipitation equilibria (gravimetry, potentiometry, conductivity measurements);

- Oxidation state and redox reactions (redox-titrations, galvanic elements);

- Metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration)

- Qualitative analysis (cation and anion separation, determination of cations and anions).
In the general chemistry practical course students are introduced to the work in chemistry laboratory. During the course they become familiar with common chemistry glassware and related equipment as well as learn basic experimental procedures, such as distillation, recrystallization, purification, digestion etc. Upon the measurements of pH, conductivity, and potential in the course of reactions, students establish the understanding of the chemical equilibrium concept.

Students work with various classes of inorganic compounds and types of chemical reactions, e.g. acid-base, redox, precipitation. They also obtain first experience with the synthesis of metal complexes as well as learn basics of qualitative analysis of an unknown substance.


Literature

Prerequisites
Voraussetzungen:
- Mathematik I und II
- Allgemeine Chemie I und II
- Physikalische Chemie I

401-0373-00L Mathematics III: Partial Differential Equations
- 4 credits
- 2V+1U
- N. Moshayedi

Abstract

Objective
Classical tools to solve the most common linear partial differential equations.

Content
1) Examples of partial differential equations
- Classification of PDEs
- Superposition principle

2) One-dimensional wave equation
- D'Alembert's formula
- Duhamel's principle

3) Fourier series
- Representation of piecewise continuous functions via Fourier series
- Examples and applications

4) Separation of variables
- Solution of wave and heat equation
- Homogeneous and inhomogeneous boundary conditions
- Dirichlet and Neumann boundary conditions

5) Laplace equation
- Solution of Laplace's equation on the rectangle, disk and annulus
- Poisson formula
- Mean value theorem and maximum principle

6) Fourier transform
- Derivation and definition
- Inverse Fourier transformation and inversion formula
- Interpretation and properties of the Fourier transform
- Solution of the heat equation

7) Laplace transform (if time allows)
- Definition, motivation and properties
- Inverse Laplace transform of rational functions
- Application to ordinary differential equations

Lecture notes
See the course web site (linked under Lernmaterialien)

Literature

Additional books:
4) E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1,2,11,12,6)

Prerequisites
Required background:
1) Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant
2) Multiple integrals: Riemann integrals in two or three variables, change of variables
2) Sequences and series of numbers and of functions
3) Basic knowledge of ordinary differential equations

 Examination Block II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0221-00L</td>
<td>Organic Chemistry I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>H. Wennemers</td>
</tr>
</tbody>
</table>

Abstract
This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

Objective
The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handled out each time and discussed one week later in the exercise class.

Content
529-0051-00L  Analytical Chemistry I  O  3 credits  3G  D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi

Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

Lecture notes
Script will be for the production price

Literature

Prerequisites
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

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5. Semester

Compulsory Subjects

Examination Block III
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0557-00L</td>
<td>Chemical Engineering Thermodynamics</td>
<td>0</td>
<td>4 credits</td>
<td>3G</td>
<td>A. de Mello, S. Stavrakis</td>
</tr>
</tbody>
</table>

**Abstract**
This course introduces the basic principles and concepts of chemical engineering thermodynamics. Whilst providing insights into the meaning and properties of fundamental thermodynamic quantities, the course also has a primary focus on the application of thermodynamic concepts to real chemical engineering problems.

**Objective**
A primary objective of the course is to present a rigorous treatment of classical thermodynamics, whilst retaining a strong engineering perspective. Accordingly, real-world engineering examples will be used to highlight how thermodynamics is applied in engineering practice. The core ideas presented and developed within the course will provide a foundation for subsequent studies in such fields as fluid mechanics, heat transfer and statistical thermodynamics.

**Content**
The first part of the course introduces the basic concepts and language of chemical engineering thermodynamics. This is followed by an analysis of energy and energy transfer, with a specific focus on the concept of work and the first law of thermodynamics. Next, the notion of a pure substance is introduced, with a discussion of the physics of phase-changes being presented. The description of pure substances is further developed through an analysis of the PVT behavior of fluids, equation of states, ideal and non-ideal gas behaviour and compressibility factors.

The second part of the course begins with a discussion of the use of the energy balance relation in closed systems that involve pure substances and then develops relations for the internal energy and enthalpy of ideal gases. Next, the second law of thermodynamics is introduced, with a discussion of why processes occur in certain directions and why energy has quality as well as quantity. Applications to cyclic devices such as thermal energy reservoirs, heat engines and refrigerators are provided. Entropy changes that take place during processes for pure substances, incompressible substances and ideal gases are described.

The third part of the course establishes thermodynamic formulations for the calculation of enthalpy, internal energy and entropy as function of pressure and temperature, Gibbs energy, fugacity and chemical potential. Two-phase systems are introduced as well as the use of equations of state to construct the complete phase diagrams of pure fluid.

The final part of the course focuses on the properties of mixtures and the phase behavior of multicomponent systems. The fundamental equations of phase equilibria in terms of the chemical potential and fugacity are also discussed. The concept of an ideal solution is introduced and developed. This is followed by an assessment of non-ideal behavior and the use of activity coefficients for describing phase diagrams. Particular focus is given to phase equilibria. Finally, concepts relating to chemical equilibrium are introduced with the general concepts developed being applied to reacting species. Examples here include the calculation of the Gibbs free energy and the equilibrium constant of a reaction.

**Lecture notes**
Lecture handouts, background literature, problem sheets and notes will be made accessible to enrolled students through the lecture Moodle site.

**Literature**
Although there is not set text for the course, the following three texts will be used in part and are excellent introductions to Chemical Engineering thermodynamics:


Resources for the acquisition of material properties and data:

1. NIST Chemistry WebBook (https://webbook.nist.gov/chemistry/)
2. CRC Handbook of Chemistry & Physics, 99th Edition (http://hbcponline.com/)

A basic knowledge of chemical thermodynamics is required.

**Prerequisites / notice**

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- **Method-specific Competencies**
  - Analytical Competencies assessed
  - Decision-making assessed
  - Problem-solving assessed
- **Personal Competencies**
  - Creative Thinking assessed
  - Critical Thinking assessed

**151-0917-00L Mass Transfer**

**Abstract**
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.

**Objective**
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.

**Content**
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

**Literature**

**Prerequisites / notice**
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.
Communication
At the end of this course students should be familiar with the basics of heat transfer and fluid dynamics, and have acquired the ability to

Microbiology
Provide to the students a complete methodology for the analysis and design of homogeneous reactors

Der Schwerpunkt liegt auf den Themen: Bakterielle Zellbiologie, Molekulare Genetik, Wachstumsphysiologie, Biochemische Diversität,

For the numerics part, see http://www.sam.math.ethz.ch/~karoger/numci/2024/

Scriptes are available on line on the web page of the Arosio group.

Analytical Competencies
fostered
Concepts and Theories
assessed
Techniques and Technologies
fostered

Kinetic models for homogeneous reactions. Collection and analysis of experimental rate data. Isothermal ideal reactors. Complex reaction

Concepts and Theories
assessed
Techniques and Technologies
assessed

O
2V+2U
fostered
Kinetics of homogeneous reactions. Ideal reactors: optimization of conversion and selectivity for complex kinetic networks. Thermal effects

Kinetic models for homogeneous reactions. Collection and analysis of experimental rate data. Isothermal ideal reactors. Complex reaction

Kinetic models for homogeneous reactions. Collection and analysis of experimental rate data. Isothermal ideal reactors. Complex reaction

ECTS
fostered
Adaptability and Flexibility
fostered
Creative Thinking
assessed
Critical Thinking
assessed

For the statistics part, see  http://stat.ethz.ch/lectures/as24/statistical-numerical-methods.php

- Statistical experimental design
- Multivariate analysis

For the statistics part, see http://stat.ethz.ch/lectures/as24/statistical-numerical-methods.php

Recommended reading:
4) W. A. Stahel, Statistische Datenanalyse, Vieweg, 4th edition 2002

529-0636-00L
Heat Transport and Fluid Dynamics ■  O  4 credits  4G  A. A. Kubik

Abstract
This course teaches the basis and the methods for the description and for the quantitative treatment of heat transfer and fluid flow with

Objective
At the end of this course students should be familiar with the basics of heat transfer and fluid dynamics, and have acquired the ability to
describe these phenomena in practical processes and to perform corresponding calculations

Content
Mechanisms of heat and momentum transfer; analogy between mass, heat and momentum transfer; dimensional analysis; kinematics and
continuum mechanics; steady and non-steady; laminar and turbulent flow; inviscid flows; Bernoulli equation; Navier-Stokes equations;
boundary layer theory; steady and non-steady heat conduction; convective heat transfer; heat transfer correlations; radiative heat transfer

Lecture notes
Lecture notes will be handed out

Examination Block IV

Number  Title  Type  ECTS  Hours  Lecturers
529-0632-00L  Homogeneous Reaction Engineering  O  4 credits  3G  P. Arosio

Abstract
Kinetics of homogeneous reactions. Ideal reactors: optimization of conversion and selectivity for complex kinetic networks. Thermal effects
in chemical reactors. Residence time distribution. Analysis and design of real reactors. Fast reactions in turbulent flows. Sensitivity and
stability of chemical reactors

Objective
Provide to the students a complete methodology for the analysis and design of homogeneous reactors

Content
Kinetic models for homogeneous reactions. Collection and analysis of experimental rate data. Isothermal ideal reactors. Complex reaction
networks. Reactor design for conversion and selectivity optimization. Adiabatic and non-isothermal reactors. Temperature effect on
Parametric sensitivity and stability in chemical reactors.

Literature

752-4001-00L  Microbiology  O  2 credits  2V  M. Schuppner, M. La Fortezza, M. Pilhofer, S. Robinson

Abstract
Some parts of the lecture will be taught in English.
Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial
Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

Objective
Teaching of basic knowledge in microbiology.

Content
Der Schwerpunkt liegt auf den Themen: Bakterielle Zellbiologie, Molekulare Genetik, Wachstumsphysiologie, Biochemische Diversität,
Phylogenie und Taxonomie, Prokaryotische Vielfalt, Interaktion zwischen Menschen und Mikroorganismen sowie Biotechnologie.

Literature
Wird von den jeweiligen Dozenten ausgegeben.

Literature
Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

Competencies
Subject-specific Competencies
Concepts and Theories
assessed
Techniques and Technologies
assessed

401-0675-00L  Statistical and Numerical Methods for Chemical Engineers  O  3 credits  2V+2U  R. Käppeli, P. Müller, C.-J. Shih

Abstract
This course covers common numerical algorithms and statistical methods used by chemical engineers to solve typical problems arising in
industrial and research practice.

Objective
This course covers common numerical algorithms and statistical methods used by chemical engineers to solve typical problems arising in
industrial and research practice. The focus is on application of these algorithms to real world problems, while the underlying mathematical
principles are also explained. The MATLAB environment is adopted to integrate computation, visualization and programming.

Content
Topics covered:
Part I: Numerical Methods:
- Interpolation & Numerical Calculus
- Non-linear Equations
- Ordinary Differential Equations
- Partial Differential Equations
- Linear and Non-linear Least Squares

Part II: Statistical Methods:
- Data analysis and regression methods
- Statistical experimental design
- Multivariate analysis

Lecture notes
For the numerics part, see http://www.sam.math.ethz.ch/~karoger/numci/2024/

Literature
For the statistics part, see http://stat.ethz.ch/lectures/as24/statistical-numerical-methods.php

Recommended reading:
4) W. A. Stahel, Statistische Datenanalyse, Vieweg, 4th edition 2002
Discovering Management

Does not take place this semester.

Entry level course in management for BSc, MSc and PHD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Excercises) 351-0778-01.

Abstract

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship. In particular, the aims of the course are to:

1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and/or appreciate the challenges that entrepreneurs and managers deal with.

Content

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges.

The practice sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Competencies

Subject-specific Competencies

Concepts and Theories

Analytical Competencies

Problem-solving

Method-specific Competencies

Social Competencies

Cooperation and Teamwork

Self-presentation and Social Influence

Personal Competencies

Creative Thinking

Critical Thinking

Self-direction and Self-management

351-1159-00L Technology Entrepreneurship for Chemical Engineers

Only for students in BSc Chemical Engineering.

Abstract

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

Objective

This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures.

A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases. The project work links technology entrepreneurship with challenges in the chemical industry.

Content

Weekly sessions - recorded.

10+ sessions carried out by guest lecturers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

Typical lecture format (2h):

15': Introduction
60': Guest testimonial
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Special workshops will complement the course.

Laboratory Courses and Case Studies

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---

Abstract

The focus of part I of the case study course lies on the literature-based comparison of chemical process alternatives. Based on this compilation and selected quantitative as well as qualitative measures, a process assessment and comparison is conducted. A basic flowsheet is then generated, and mass and energy balances are performed to carry out a preliminary economic and environmental assessment.

Objective

- to obtain knowledge about different databases and sources of information
- application of the knowledge obtained in lectures to a real problem
- problem-oriented problem solving (application of different methods to the same subject)
- team work
- report writing and presentation techniques
The focus of part I of the case study course lies on the literature-based comparison of chemical process alternatives. For this purpose, relevant substance data (i.e. physico-chemical, toxicological, safety, and environmental data), as well as information about synthesis routes and technical implementations (i.e. on reaction kinetics; possible separation operations; economic, safety, and environmental aspects), are collected from the literature. Based on this compilation and selected quantitative as well as qualitative measures, a process assessment and comparison is conducted and the most promising process alternative is chosen for further evaluation. For this alternative, a basic flowsheet and mass and energy balances are generated.

Abstract

The internship is exclusively for chemical engineering BSc 05 semester students. For justified exceptions, please contact the teaching staff before the start of the semester.

Objective

Introduction to various tools of chemical engineering techniques with reference to the running lectures. In groups of two, students will conduct experiments in the following areas: thermodynamics and phase equilibria including electrochemistry, transport phenomena, kinetics and selectivity of complex reactions, characterisation of ideal and real reactors.

Content

In groups of two, students will conduct selected experiments in the following areas: thermodynamics and phase equilibria including electrochemistry, transport phenomena, kinetics and selectivity of complex reactions, characterisation of ideal and real reactors.

Prerequisites / notice

Registration for the course unit is only possible for the primary target group (Chemical Engineering Bachelor 05 semester students).

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Chemical Engineering Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O Compulsory</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>W+ Eligible for credits and recommended</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>W Eligible for credits</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P practical/laboratory course</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
</tr>
</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Comparative and International Studies Master

Core Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>857-0001-00L</td>
<td>Methods I: Research Design, Qualitative Methods, and Data Collection</td>
<td>O</td>
<td>6 credits</td>
<td>2U+2S</td>
<td>A. Abdelrahman, F. Schimmelfennig, S. Hegewald, L. Kakhishvili, J. Kissling</td>
</tr>
</tbody>
</table>

Abstract
The seminar covers basic issues of research design, small-n research, and data collection. It deals with issues of causality, conceptualization, case study design and QCA. Data collection includes interviews, surveys, text analysis, and experimental research.

Objective
This MACIS core seminar covers basic issues of research design, small-n research, and data collection. It familiarizes students with general research design problems such as defining research questions, analyzing causality, and designing single and comparative case studies. It then introduces them to basic issues in small-n research. Students acquire an understanding of the specific challenges and design problems in qualitative analysis. Finally, students are introduced to exemplary methods of data collection. By the end of the course, students should be able to use the principal methods of data collection used by political scientists; have a critical understanding of the advantages and disadvantages of the methods, and should be able to reflect on and discuss the methods in light of research questions of their interest.

Competencies
Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
Method-specific Competencies: Analytical Competencies, Project Management
Social Competencies: Communication
Personal Competencies: Creative Thinking, Critical Thinking

857-0007-00L | Democracy | W | 8 credits | 2S | F. Schimmelfennig, D. Kübler |

Abstract
The seminar focuses on seminal books and articles as well as brand new analyses on topical issues of democratic theory and practice. After reviewing theoretical models and different types of democracy, the seminar deals with core problems of democratic governance and with challenges to democracy stemming from globalization and international institutions.

Objective
At the end of the seminar, students are familiar with the relevant theoretical and empirical literature on democracy and democratization in national and international contexts. They are able to reflect on contemporary challenges to democracy, in particular those stemming from the internationalization of politics.

Content
see http://www.cis.ethz.ch/education/macis/courses

Literature
see http://www.cis.ethz.ch/education/macis/courses

Competencies
Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Analytical Competencies, Communication
Social Competencies: Cooperation and Teamwork
Personal Competencies: Creative Thinking, Critical Thinking

857-0009-00L | Political Violence | W | 8 credits | 2S | A. Wenger, C. Bara |

Abstract
This course offers an introduction to political violence in domestic and international politics. The course covers explanations of interstate wars, theories of civil and ethnic wars and regional conflict. Other topics include new threats, including transnational terrorist networks and other non-state actors, and the relationship between conflict and nation-building and democratization processes.

Objective
This course offers an introduction to political violence in domestic and international politics. The course covers explanations of interstate wars, theories of civil and ethnic wars and regional conflict. Other topics include new threats, including transnational terrorist networks and other non-state actors, and the relationship between conflict and nation-building and democratization processes.

857-0009-00L | Methods II: Quantitative Methods | O | 6 credits | 2U+2S | N. Berk, P. Grech |

Abstract
This class provides an introduction to quantitative methods for social science and policy analysis. The class covers statistical inference, introductory probability, descriptive statistics, regression, and statistical and database programming.

Objective
After this course, students should be able to assemble a dataset, prepare descriptive statistics, develop and test hypotheses, and present their results in a high-quality presentation or paper.

Research Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>857-0103-00L</td>
<td>Topics in Public Policy: Governing the Energy Transition</td>
<td>W</td>
<td>8 credits</td>
<td>2S</td>
<td>L. P. Fesenfeld, T. Schmidt</td>
</tr>
</tbody>
</table>

Abstract
This course addresses the role of policy change and its underlying politics in the transformation of the energy and other climate and sustainability-related sectors. It focuses on political perspectives (while also touching on historical and socio-economic perspectives) and applies various theoretical concepts to understand specific aspects of transition governance.

Objective
- To gain an overview of the history of the transition of large socio-technical systems
- To recognize challenges for transformative policy change and to understand the theoretical frameworks and concepts for studying transitions
- To develop own research question and address it in research paper that demonstrates knowledge of the role of policy and politics in transitions

Content
Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the recent United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of socio-technical systems necessary. This course introduces the social and environmental challenges involved in the energy sector as a key sector in need of transition. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It then focuses on the role of public policy and policy change in governing complex socio-technical transitions, considering the role of political actors, institutions and policy feedback.

The course has a highly interactive (seminar-like) character. Students are expected to actively engage in the weekly discussions and to give a presentation (15-20 minutes) on one of the weekly topics during that particular session. In addition to the weekly lectures, students will write a research paper of approximately 6000 words, guided by and in collaboration with the lecturers.

Active participation in the seminar (15%) and the presentation (15%) will form one part of the final grade, with the research paper forming the rest (70%).

Lecture notes
Slides and reading material will be made available via moodle.ethz.ch (only for registered students).

Literature
A reading list will be provided via moodle.ethz.ch at the beginning of the semester.
This course is intended for the MA Comparative International Studies programme.

### 857-0104-00L

**Topics in Public Policy: The Politics and Policies of International Migration**

*Does not take place this semester.*

**Abstract**
This seminar will provide a collaborative and immersive research experience where students work together with the instructor to design and implement a randomised experiment to study topical questions related to the politics or policies of international migration.

**Objective**
Upon completion, course participants will have first-hand experience with collaborative research including project management, spanning the entire project cycle from ideation, study design and pre-analysis planning, field phase and data collection, statistical analysis and paper writing.

**Literature**
The reading materials consist of a series of academic papers (see detailed syllabus)

**Prerequisites / notice**

### 857-0052-00L

**Comparative and International Political Economy**

*ECTS Concepts and Theories*

**Abstract**
This research seminar complements the MACIS core seminar in Political Economy. It covers topics such as international trade, environmental policy, international finance and foreign direct investment, and welfare state policy. Students will, based on reading assignments and discussions in class, develop a research question, present a research design, and write a paper.

**Objective**
Students will acquire an advanced understanding of some of the key issues and arguments in comparative and international political economy. They will also prepare the ground for a high-quality MA thesis in political economy.

**Content**
Because the number of students will be very small, the Political Economy core course runs in parallel, and research interests will be heterogeneous, the general approach will be informal and decentralized. Before the seminar starts we will identify what research topics - within the broader field of Comparative and International Political Economy - the participating students are most interested in. In the first two weeks of the semester, we will meet twice for two hours each as a group to discuss how to write a good research seminar paper, and to identify more closely what each student will be working on. Each student will then receive a reading list, so that she/he can get familiar with the state-of-the-art in her/his area of interests and develop a research design in close consultation with Profs. Bernauer and Koubi as well as postdocs from Prof. Bernauer's group. The group as a whole meets again ca. in week 7 of the semester to discuss the provisional research designs. Research then continues in a decentralized fashion - again in consultation with Profs. Bernauer and Koubi as well as postdocs from Prof. Bernauer's group. The group as a whole meets again in the second to last week of the semester. Each student reports on progress in her/his research during that meeting. The research seminar paper must be finalized and submitted by the end of July 2015.

**Prerequisites / notice**
This seminar is restricted to students enrolled in the MACIS program.

### 857-0106-00L

**International Environmental Politics (with Research Paper)**

*Does not take place this semester.*

**Abstract**
Based on the contents of the International Environmental Politics lecture (860-0023-00L) students will develop a research question and study design on a topic of their choice, carry out independent research and write a research paper under the supervision of Prof. Bernauer as well as postdocs and doctoral students in his research group.

**Objective**
Acquire skills for carrying out independent research and writing a research paper in the area of international environmental politics.

**Competencies**

**Social Competencies**
Communication
Project Management

**Method-specific Competencies**
Analytical Competencies
Media and Digital Technologies
Problem-solving

**Subject-specific Competencies**
Decision-making

**Personal Competencies**
Creative Thinking
Critical Thinking

**Prerequisites / notice**
MACIS students are given priority.

### 857-0108-00L

**Introduction to Security Studies**

*Does not take place this semester.*

**Abstract**
This seminar introduces students to international security studies research by covering a substantive topic in the field each week (such as war, nuclear weapons, etc.). Students will study the discipline's fundamental questions and will engage with how scholars generate knowledge as well as the various research designs, inferential strategies, and analytical methods they have used.

**Objective**
Students will study the discipline's fundamental questions, such as why wars occur, if there are ways to make the outbreak of war less likely, and what the advent of nuclear weapons and emergent technologies means for international affairs. The course will also expose students to recent debates and research in the field. It will cover how scholars have generated knowledge as well as the various research designs, inferential strategies, and analytical methods they have used. After completing the course, students should have increased familiarity with essential readings in international security studies and the skills to conduct meaningful independent research.

### 857-0111-00L

**Researching Peace and Security**

**Abstract**
The seminar offers an in-depth exploration of cutting-edge peace and security research. The course is structured around key themes and current developments in the field. It combines theoretical foundations with practical case studies as well as exercises and presentations, aiming to equip students with the knowledge and skills necessary to conduct rigorous research in peace and security studies.

**Objective**
The aim of this research seminar is to introduce students to cutting-edge research in peace and security studies, have them reflect critically on the development and main focal points, and to give them enough theoretical background so that they can write research papers on a relevant topic of their choice. In each session, senior researchers from the Center for Security Studies will talk about their own research. Several research design sessions cover the entire research process, from identifying compelling research puzzles and questions to matching theoretical frameworks with data and methods, conducting ethical field research, and writing high-quality research papers. Each session will involve introductory lectures, followed by discussions of key texts, and interactive activities to foster a deep understanding of the topics covered. Students will present their own research design in class and will receive feedback how to improve their approach to their chosen research topics.

### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>860-0023-00L</td>
<td>International Environmental Politics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>T. Bernauer</td>
</tr>
</tbody>
</table>

*Particularly suitable for students of D-ITET, D-USYS.*
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined.

The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they or could be solved.

This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

This course draws out good practices in promoting sustainability development at the city level. Participants gain insights on designing urban- focused development interventions.

Registration only through the NADEL administration office.
Historically, cities have been hubs of innovation, economic activity and rising prosperity. However, the unprecedented speed and scale at which cities are growing today is a huge challenge. As epicenters of migration, environmental degradation, health hazards and unemployment, urban areas are especially vulnerable to disasters, social conflict and inequality. Despite this, some of the most promising initiatives to achieve the SDGs have been implemented by cities. What strategies and processes do successful city- based initiatives pursue? How can development organisations support mainstreaming the SDGs at the local level? What can be learnt from experiences so far? This course draws out good practices in promoting sustainability and equity at the city and local level. Participants gain insights on designing urban- focused development interventions.

**Prerequisites / notice**
Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with the NADEL secretariat.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Analytical Competencies</th>
<th>Critical Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>assessed</td>
<td>fostered</td>
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<tr>
<td>865-0002-00L</td>
<td>Migration and Development</td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
</tr>
</tbody>
</table>

**Objective**

Content

Key Topics:
- Drivers, dynamics and challenges of urbanization
- The urban- rural continuum – why does it matter?
- Localisation of global development and sustainability agendas: challenges and opportunities
- Three to four case studies selected from the following: informal settlements, urban food systems, WASH, children’s well- being, circularity, migration.

**CompeTencies**

**Subject-specific Competencies**
- Concepts and Theories
- Analytical Competencies
- Critical Thinking

**Method-specific Competencies**
- Cooperative and Teamwork
- Critical Thinking

**Personal Competencies**

**Prerequisites**

- Only for MAS/CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

**Abstract**

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

**Registration only through the NADEL administration office.**

**Objective**

Course participants have improved understanding of the following issues:
- Definition of migration concepts and terms
- International legal frameworks related to migration
- The geography of migration flows
- Major drivers of migration
- The evolving concept of "migration and development"
- International cooperation organisations and their strategies and activities in terms of migration and development.

**Content**

Globally, over 280 million people live outside their countries of origin. While the concept of migration has negative connotations for some, migration can bring significant benefits – to both countries of origin and destination, if the right policies and initiatives are in place. The course explores the role that international cooperation can play in promoting the positive aspects of migration.

The course explores the role that international cooperation can play in promoting the positive aspects of migration. Migration is multifaceted, and driven by various, often interlinked factors including conflict and violence, economic, social and political factors, as well as environmental and climate related events. While the concept of migration has negative connotations for some, migration can bring significant benefits – to both countries of origin and destination, if the right policies and initiatives are in place. The course explores the role that international cooperation can play in promoting the positive aspects of migration and in reducing the potential negative consequences.

**This course covers: **
- important terms and concepts related to migration;
- international legal frameworks related to migration;
- the geography of migration flows;
- major drivers of migration;
- the evolving concept of migration and development;
- actions, strategies and initiatives of international cooperation actors when it comes to migration and development.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Analytical Competencies
- Cooperation and Teamwork
- Critical Thinking

**Registration only through the NADEL administration office.**

**Objective**

The course enables participants to understand the significance of the engagement of civil society organisations in policy processes in order to overcome exclusion and foster voice. The course acquaints participants with concepts and practice of civil society participation in shaping policies at micro and macro level and provides practical tools for influencing political processes.

Recognizing that development is inherently political, this course covers political processes and how they intertwine with the goals and strategies of various agents in international cooperation. It discusses the significance and implications of civil society’s efforts to foster voice and inclusion. The course provides a nuanced understanding of different strategic options and approaches to contribute to policy processes and offers tools that have proven to be effective in practical development cooperation. It provides an opportunity for participants to apply concepts related to the strengthening of civil society to their projects and case studies.

**Prerequisites**

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### Gender and Economics

**W**

Only for MAS/CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

**Content**
- Feminist approaches to macroeconomics, microeconomics and international economics
- Critical analysis of global and regional economic trends, including those related to economic crises
- Gender-responsive economic policy for program implementation, policymaking, and advocacy

**Objective**
- The overall objective of the course is to strengthen the capacity of technical advisors and program staff on the importance of gender-responsive economic policy. The course conveys basic knowledge about gender aspects in economics. Key elements are:
- Economic inequalities between men and women persist in many countries. For example, in many countries, men earn more money and are more likely to own land and control productive assets than women. This course on gender and economics is intended to provide basic- and intermediate-level training to development practitioners and policy and program staff in international development agencies.
- Students of the course must fulfil requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with NADEL secretariate.

**Prerequisites / notice**
- Policy in terms of rules and norms emerging from a negotiation process between interdependent actors
- Exclusive and fragile institutions, and the influence of dominant coalitions

865-0012-00L  Gender and Economics  W  3 credits  3G  M. Malefakis

### Health and Development

**W**

MAS ETH in Global Cooperation and Sustainable Development students have priority for admission.

**Content**
- Economic inequalities between men and women persist in many countries. For example, in many countries, men earn more money and are more likely to own land and control productive assets than women. This course on gender and economics is intended to provide basic- and intermediate-level training to development practitioners and policy and program staff in international development agencies. The overall objective of the course is to strengthen the capacity of technical advisors and program staff on the importance of gender-responsive economic policy. The course is taught in cooperation with SDC and UN women.

**Objective**
- The overall objective of the course is to strengthen the capacity of technical advisors and program staff in international development agencies.

**Prerequisites / notice**
- Policy in terms of rules and norms emerging from a negotiation process between interdependent actors
- Exclusive and fragile institutions, and the influence of dominant coalitions

865-0069-00L  Health and Development  W  2 credits  2G  K. Harttgen

### Agriculture, Food and Nutrition Security

**W**

MAS ETH in Global Cooperation and Sustainable Development students have priority for admission.

**Content**
- Food security has been on top of the policy agenda for decades, but still a considerable proportion of the population in developing countries remains hungry and poorly nourished. This lecture series will explore how we produce and distribute food; it analyses the concept of food and nutrition security and discusses ways and means for measuring and achieving it in low-income countries.

**Objective**
- The student will be able to:
  - describe the most important milestones in the history of food and agriculture
  - understand the concept of food and nutrition security, and discuss its impact and causes
  - compare different approaches to promote and increase crop- and livestock production in a sustainable manner
  - reflect on some of the main economic challenges of the world food system and understand some of the tradeoffs between smallholders’ decisions of labor, consumption, and production of food
  - give insights on how international organizations work with farmers and governments in low income countries

**Competencies**
- Reflect on some of the main economic challenges of the world food system and understand some of the tradeoffs between smallholders’ decisions of labor, consumption, and production of food
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865-0010-02L  Agriculture, Food and Nutrition Security  W  2 credits  2G  S. Patel

### Water, Sanitation and Waste Management

**W**

MAS ETH in Global Cooperation and Sustainable Development students have priority for admission.

**Content**
- The course provides an overview of the links among sanitation, water supply, waste management and environmental and health aspects. It gives an understanding of the specific challenges and possible solutions in ensuring environmental services and illustrates their impact on the population and settlements.

**Objective**
- The participants are able to:
  - present the global situation and development trends in the sector of sanitation, water supply, waste management and for its main actors;
  - discuss the relationships between water supply, sanitation and health;
  - explain the principles of technologies for drinking water treatment, the management of sewage and waste, as well as appraise their strengths and weaknesses;
  - explain which sustainable concepts are implemented and how they can be inserted into the technical, institutional and social structures so that they are economically, ecologically and socially sustainable.
  - provide information where good professional resources are available.

865-0011-01L  Water, Sanitation and Waste Management  W  2 credits  2G  I. Günther
Abstract
Understanding a society’s economic, social, and market outcomes requires one to understand its politics. Yet, a common view is that politics is unpredictable and unintelligible—in this course, we push against this view. We will use game-theoretic tools from economics to analyze politics in a structured and principled way and to develop new insights into policy making and regulatory decisions.

Objective
The objective of this course is to introduce students to the formal analysis of politics, via economic models.

Content
This course will introduce students to a variety of foundational economic models of politics and policy making. This includes—but is not limited to—models of electoral competition, political agency, legislative bargaining, and the interaction between political and market outcomes (e.g., via market and business regulations).

The course material will mainly be theoretical and mathematical (primarily using game theory). Real-world examples and empirical research will be discussed to help motivate and evaluate the theoretical material. Most of the content will focus on the United States, for which rich theoretical and empirical literatures exist. However, the key tools, ideas, and insights can be applied more generally and beyond the United States.

The course assumes basic mathematical competencies (e.g., familiarity with algebra, multi-variable calculus, and probability). We will not assume prior knowledge of game theory—the course will introduce game theoretic concept as they are required. However, having previously taken an introductory course in game theory will be an advantage (e.g., D-MTEC courses such as: 363-0558-00L “Introduction to Game Theory: Strategic and Cooperative Thinking” or the recent edition of 363-0515-00L “Decisions, Markets, and Games”).

Literature
The course material primarily draws from the following textbooks:

Other useful resources:

Prerequisites / notice
There are no formal admission requirements. It is expected that students have a basic level of mathematical competence. It will be beneficial if students have taken an undergraduate level course in microeconomics or game theory.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

► Master’s Thesis

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<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>857-0019-00L</td>
<td>Master’s Thesis Colloquium</td>
<td>O</td>
<td>4</td>
<td>3K</td>
<td>J. Spirig</td>
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Abstract
Permission to begin master thesis is required to take part in Colloquium.

Objective
In this colloquium, students enrolled in the MACIS program first present and discuss research design and methods issues concerning their prospective MA theses. Towards the end of the semester they present preliminary findings from their MA thesis work.

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<td>O</td>
<td>26</td>
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</table>

Abstract
The Master Thesis is an independent piece of research on an issue in comparative and international politics. It combines theory, methods, and empirical work.

Objective
The Thesis should demonstrate the students’ ability to conduct independent research on the basis of the theoretical and methodological knowledge acquired during the MA program.

Comparative and International Studies Master - Key for Type

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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
<td>Suitable for doctorate</td>
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<td>Key for Hours</td>
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<td>V</td>
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<td>G</td>
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<td>S</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS: European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data.

The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.

The object of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

The course must be registered for directly at Uni Basel.

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

* *Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.*
* *Felsenstein, J. 2004. Inferring Phylogenies.*
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* *Felsenstein, J. 2004. Inferring Phylogenies.*
* *Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.*

Lectures notes

Lecture notes will be available on moodle.

Literature

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* *Felsenstein, J. 2004. Inferring Phylogenies.*
* *Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.*

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Competencies

Subject-specific Competencies

Concepts and Theories

Assessed

Method-specific Competencies

Analytical Competencies

Assessed

Problem-solving

Assessed

Social Competencies

Communication

Fostered

Cooperation and Teamwork

Fostered

Personal Competencies

Critical Thinking

Assessed

Self-direction and Self-management

Fostered
Abstract
Evolutionary genetics covers three important areas of modern evolutionary genetics: bioinformatics, molecular evolution and population genetics. Treating these three areas together in a single course provides an integrated education in evolutionary genetics. A solid understanding of these areas is also central to other fields such as conservation biology or behavioural and evolutionary ecology.

262-6110-00L Bioinformatics Algorithms (University of Basel)  
The course must be registered for directly at Uni Basel.  
Uni Basel course number: 45401-01

Abstract
Mind the enrolment deadlines at Uni Basel:  
https://www.unibas.ch/en/Studies/Mobility/Mobility-Switzerland/Students-Registering-From-Other-Swiss-Universities.html

Objective
Students can understand the main algorithmic design principles for problems like sequence alignment, motif finding and phylogenetic inference. Further, students get an overview of modern machine learning methods and their applications to bio-medical problems.

401-6282-00L Statistical Analysis of High-Throughput Genomic and Transcriptional Data (University of Zurich)  
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.  
UZH Module Code: STA426

Abstract
A range of topics will be covered, including basic molecular biology, genomics technologies and in particular, a wide range of statistical and computational methods that have been used in the analysis of DNA microarray and high throughput sequencing experiments.

Objective
- Understand the fundamental "scientific process" in the field of Statistical Bioinformatics  
- Be equipped with the skills/tools to preprocess genomic data (Unix, Bioconductor, mapping, etc.) and ensure reproducible research (Sweave)  
- Have a general knowledge of the types of data and biological applications encountered with microarray and sequencing data  
- Have the ability to apply statistical methods/knowledge/software to a collaborative biological project  
- Gain the ability to critical assess the statistical bioinformatics literature

Content
Lectures will include: microarray preprocessing; normalization; exploratory data analysis techniques such as clustering, PCA and multidimensional scaling; Controlling error rates of statistical tests (FPR versus FDR versus FWER); limma (linear models for microarray analysis); mapping algorithms (for RNA/ChIP-seq); RNA-seq quantification; statistical analyses for differential count data; isoform switching; epigenomics data including DNA methylation; gene set analyses; classification

Lecture notes
Lecture notes, published manuscripts

Prerequisites / notice
Prerequisites: Basic knowledge of the programming language R, sufficient knowledge in statistics

Former course title: Statistical Methods for the Analysis of Microarray and Short-Read Sequencing Data

Biophysics

Number  Type  ECTS  Hours  Lecturers
262-6106-00L  W  6 credits  3G  external organisers

Abstract
This course reviews how ideas and concepts from physics have helped understanding biological systems by discussing landmark papers in the field.

636-0104-00L Biophysical Methods  
W  4 credits  3G  D. J. Müller

Abstract
Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective
Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

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### Content

The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

The biophysical methods to be taught will include:
- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
- X-ray, electron and neutron diffraction
- MRI imaging
- Scanning tunnelling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations

### Lecture notes

Hand out will be given to students at lecture.

### Literature

Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press


### Prerequisites / notice

The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the semester, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

### 529-0004-01L

**Classical Simulation of (Bio)Molecular Systems**

- **W** 6 credits
- **4G**
- **P. H. Hünenberger, J. Dolenc, S. Riniker**

#### Abstract

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

#### Objective

Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

#### Content

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

#### Lecture notes

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

#### Literature

See: www.csms.ethz.ch/education/CSBMS

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

#### Competencies

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Media and Digital Technologies
  - Problem-solving

- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking

#### 636-0007-00L

**Computational Systems Biology**

- **W** 6 credits
- **3V+2U**

#### Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

#### Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

#### Content

Biologist has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label “Systems Biology”, focuses on how networks, which are more than the mere sum of their parts’ properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles. We will also be relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

#### Lecture notes

http://www.csb.ethz.ch/education/lectures/lectures.html

#### Literature


636-0706-00L Spatio-Temporal Modelling in Biology

Abstract
This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on mechanisms and concepts, but mathematical and numerical techniques are introduced as required. Biological examples discussed in the course provide an introduction to key concepts in developmental biology.

Objective
Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

Content
1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

Lecture notes
All lecture material will be made available online via Moodle.

Literature
The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:

- Murray, Mathematical Biology, Springer
- Forgacs and Newman, Biological Physics of the Developing Embryo, CUP
- Keener and Sneyd, Mathematical Physiology, Springer
- Fall et al, Computational Cell Biology, Springer
- Szallasi et al, System Modeling in Cellular Biology, MIT Press
- Wolkenhauer, Systems Biology
- Kreyszig, Engineering Mathematics, Wiley

Prerequisites / notice
The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

636-0117-00L Mathematical Modelling for Bioengineering and Systems Biology

Abstract
Basic concepts and mathematical tools to explore biochemical reaction kinetics and biological network dynamics.

Objective
The course enables students to formulate, analyse, and simulate mathematical models of biochemical networks. To this end, the course covers basic mathematical concepts and tools to explore biochemical reaction dynamics as well as basic concepts from dynamical systems theory. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.

Content
Biochemical Reaction Modelling
Basic Concepts from Linear Algebra & Differential Equations
Mathematical Methods: Linear Stability Analysis, Phase Plane Analysis, Bifurcation Analysis
Dynamical Systems: Switches, Oscillators, Adaptation Signal Propagation in Signalling Networks Parameter Estimation

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

Data Science

Number Title Type ECTS Hours Lecturers
252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

636-0101-00L Systems Genomics W 4 credits 3G B. Treutlein, C. Beisel, Z. He

Abstract

This course is an introduction to the wide field of Genomics. It addresses how fundamental questions in biological systems are studied

Objective


Content

Course material Script, computer demonstrations, exercises and problem solutions

Computational Biology and Bioinformatics Seminar

Number of participants limited to 30.

The seminar is addressed primarily at students enrolled in

Number Title Type ECTS Hours Lecturers
636-0704-00L Computational Biology and Bioinformatics Seminar O 2 credits 2S N. Beerenwinkel, D. Iber, T. Stadler

The CBB seminar is mandatory.

Seminar

The CBB seminar is mandatory.

Number Title Type ECTS Hours Lecturers
636-0704-00L Computational Biology and Bioinformatics Seminar O 2 credits 2S N. Beerenwinkel, D. Iber, T. Stadler

The seminar is addressed primarily at students enrolled in

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

636-0101-00L Systems Genomics W 4 credits 3G B. Treutlein, C. Beisel, Z. He

Abstract

This course is an introduction to the wide field of Genomics. It addresses how fundamental questions in biological systems are studied

Objective


Content

Course material Script, computer demonstrations, exercises and problem solutions

Computational Biology and Bioinformatics Seminar

Number of participants limited to 30.

The seminar is addressed primarily at students enrolled in

Number Title Type ECTS Hours Lecturers
636-0704-00L Computational Biology and Bioinformatics Seminar O 2 credits 2S N. Beerenwinkel, D. Iber, T. Stadler

The CBB seminar is mandatory.

Seminar

The CBB seminar is mandatory.

Number Title Type ECTS Hours Lecturers
636-0704-00L Computational Biology and Bioinformatics Seminar O 2 credits 2S N. Beerenwinkel, D. Iber, T. Stadler

The seminar is addressed primarily at students enrolled in
the MSc CBB programme. 

Students of other ETH study programmes interested in this course need to ask the lecturer for permission to enrol in the course.

The Seminar will be offered in autumn semester in Basel (involving professors and lecturers from the University of Basel) and in spring semester in Zurich (involving professors and lecturers from the University of Zurich). Professors and lecturers from ETH Zurich are involved in both semesters. 

Uni Basel lecturers: Richard Neher, Attila Becskei, Mihaela Zavolan, Erik van Nimwegen

Abstract

Computational biology and bioinformatics aim at an understanding of living systems through computation. The seminar combines student presentations and current research project presentations to review the rapidly developing field from a computer science perspective. Areas: DNA sequence analysis, proteomics, optimization and bio-inspired computing, and systems modeling, simulation and analysis.

Objective

Studying and presenting fundamental papers of Computational Biology and Bioinformatics. Learning how to make a scientific presentation and how classical methods are used or further developed in current research.

Content

Computational biology and bioinformatics aim at advancing the understanding of living systems through computation. The complexity of these systems, however, provides challenges for software and algorithms, and often requires entirely novel approaches in computer science. The aim of the seminar is to give an overview of this rapidly developing field from a computer science perspective. In particular, it will focus on the areas of (i) DNA sequence analysis, sequence comparison and reconstruction of phylogenetic trees, (ii) protein identification from experimental data, (iii) optimization and bio-inspired computing, and (iv) systems analysis of complex biological networks.

The seminar combines the discussion of selected research papers with a major impact in their domain by the students with the presentation of current active research projects / open challenges in computational biology and bioinformatics by the lecturers. Each week, the seminar will focus on a different topic related to ongoing research projects at ETHZ, University of Basel and University of Zurich, thus giving the students the opportunity of obtaining knowledge about the basic research approaches and problems as well as of gaining insight into (and getting excited about) the latest developments in the field.

Literature

Original papers to be presented by the students will be provided in the first week of the seminar.

 grote Courses

A total of 30 ECTS needs to be acquired in the Advanced Courses category. Thereof at least 16 ECTS in the Theory and at least 10 ECTS in the Biology category.

Theory

At least 16 ECTS need to be acquired in this category.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-0663-00L</td>
<td>Numerical Methods for Computer Science</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2R</td>
<td>V. C. Gradinaru</td>
</tr>
</tbody>
</table>

Abstract

The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.

Objective

* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently

Autumn Semester 2024

Data: 02.07.2024 12:39
First two weeks: A gentle introduction to C++

1. Computing with Matrices and Vectors
   1.1 Fundamentals
   1.2 Software and Libraries
   1.4 Computational Effort
   1.5 Machine Arithmetic and Consequences

2. Direct Methods for (Square) Linear Systems of Equations
   2.1 Introduction: Linear Systems of Equations
   2.3 Gaussian Elimination
   2.6 Exploiting Structure when Solving Linear Systems
   2.7 Sparse Linear Systems

3. Direct Methods for Linear Least Squares Problems
   3.1 Least Squares Solution Concepts
   3.2 Normal Equation Methods
   3.3 Orthogonal Transformation Methods
     3.3.1 Transformation Idea
     3.3.2 Orthogonal/Unitary Matrices
     3.3.3 QR-Decomposition
     3.3.4 QR-Based Solver for Linear Least Squares Problems
   3.4 Singular Value Decomposition

4. Filtering Algorithms
   4.1 Filters and Convolutions
   4.2 Discrete Fourier Transform (DFT)
   4.3 Fast Fourier Transform (FFT)

5. Machine Learning of One-Dimensional Data
   (Data Interpolation and Data Fitting in 1D)
   5.1 Abstract Interpolation (AI)
   5.2 Global Polynomial Interpolation

8. Iterative Methods for Non-Linear Systems of Equations
   8.1 Introduction
   8.2 Iterative Methods
   8.3 Fixed-Point Iterations
   8.4 Finding Zeros of Scalar Functions
   8.5 Newton's Method in \( \mathbb{R}^n \)
   8.6 Quasi-Newton Method

Lecture notes
Lecture materials (PDF documents and codes) will be made available to the participants through the course web page and online repositories. Access information will be communicated in the beginning of the course.

Literature
M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002
P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

Prerequisites / notice
The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves, in case they do not know it already.

Competencies
Subject-specific Competencies
- Concepts and Theories
  - assessed
- Techniques and Technologies
  - assessed
Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - fostered
- Problem-solving
  - assessed
- Project Management
  - fostered

263-S210-00L Probabilistic Artificial Intelligence

<table>
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<tr>
<th>W</th>
<th>8 credits</th>
<th>3V+2U+2A</th>
</tr>
</thead>
</table>

A. Krause

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.
### Introduction to Mathematical Optimization

**252-0225-00L**  
**Subject:** Linear System Theory  
**Lecture notes:** Available on the course Moodle platform.  
**Preerequisites / notice:** Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Abstract**  
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of control systems.

**Objective**  
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

**Content**  
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Literature**  
Information about relevant literature will be given in the lecture.

### Signals and Systems

**151-0575-01L**  
**Subject:** Signals and Systems  
**Lecture notes:** Lecture notes available on course website.  
**Preerequisites / notice:** Control Systems I is helpful but not required.

**Abstract**  
Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

**Objective**  
Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.

**Content**  

### Concepts of Object-Oriented Programming

**252-0237-00L**  
**Subject:** Concepts of Object-Oriented Programming  
**Lecture notes:** Control Systems I is helpful but not required.

**Abstract**  
Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection.

**Objective**  
After this course, students will:
- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.

**Content**  
The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing).
- The key problems of single and multiple inheritance and how different languages address them.
- Generic type systems, in particular, Java generics, C# generics, and C++ templates.
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them.

The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing.

How to maintain the consistency of data structures.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Format</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>262-6140-00L</td>
<td>Random Processes: Theory and Applications from Physics to Finance (University of Basel)</td>
<td>W 4 credits 3G</td>
<td>external organisers</td>
<td>Will be announced in the lecture. Prerequisites: Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience.</td>
</tr>
<tr>
<td>636-0015-00L</td>
<td>An Introduction to Probability Theory and Stochastic Processes with Applications to Biology</td>
<td>W 4 credits 3G</td>
<td></td>
<td>Does not take place this semester. Abstract Biology is becoming increasingly quantitative and mathematical modeling is now an integral part of biological research. In many biological processes, ranging from gene-expression to evolution, randomness plays an important role that can only be understood using stochastic models. This course will provide the students with a theoretical foundation for developing such stochastic models and analyzing phenomena. Objective The aim of this course is to introduce certain topics in Probability Theory and Stochastic Processes that have been specifically selected with an eye on biological applications. This course will teach students the tools and techniques for modeling and analyzing random phenomena. Throughout the course, several biological applications will be discussed and students will be encouraged to do additional reading based on their research interests. Content The first half of the course will cover the basics of Probability Theory while the second half will delve into the theory of Stochastic Processes. Below is the list of topics that will be covered in the course. 1. The mathematical representation of random phenomena: The probability space, properties of the probability measure, Independence of events, Conditional probability and Bayes formula, applications to parameter inference. 2. Random Variables and their distributions: Discrete and continuous random variables, Expectation and Variance, Important Examples of Random Variables, Independent random variables and their sums, Conditional Distribution and Conditional Expectation, Markov and Chebyshev inequalities. Law of total variation, estimation of intrinsic and extrinsic noise in biological systems. 3. Convergence of Random Variables: Modes of convergence, Laws of large numbers, the central limit theorem, the law of the iterated logarithm, Applications to the analysis of cell population data. 4. Generating functions and their applications: Definition and important examples, Random Walks, Branching processes, Coalescent processes, Modeling epidemic processes and stem-cell differentiation. 5. Markov chains: Transition functions and related computations, Classification of states and classification of chains. Concepts of recurrence, transience, irreducibility and periodicity, Stationary distributions, Continuous time Markov Chain model of a biochemical reaction network. 6. Stochastic Processes: Existence and Construction, Stationary Processes, Renewal Processes, The Wiener Process, The Ergodic Theorem, Leveraging experimental techniques in Biology. 7. Introduction to the theory of Martingales: Basic definitions, Martingale differences and Hoeffding's inequality, Martingale Convergence Theorem, Crossings and convergence, Stopping times and the optional sampling theorem, Doob's maximal inequalities, Applications to the analysis of stochastic biochemical reaction networks. Literature While no specific textbook will be followed, much of the material and homework problems will be taken from the following books: An Introduction to Stochastic Processes with Applications to Biology, Linda Allen, Second Edition, Chapman and Hall, 2010. Probability And Random Processes, Grimmett and Stirzaker, Third Edition, Oxford University Press, 2001. Prerequisites / notice The course will involve a healthy balance between mathematical rigor (theorem proving) and biological applications. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.</td>
</tr>
</tbody>
</table>
Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

“Big Data” refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the “fourth paradigm”.

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that’s 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today’s technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

Content
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBR, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (? *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice
The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- “Information Systems for Engineers” (SQL, relational databases): this Fall
- “Big Data for Engineers” (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered

Social Competencies
- Communication: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: assessed
Abstract
Research in Biology and Medicine have been transformed into disciplines of applied data science over the past years. Not only size and inherent complexity of the data but also requirements on data privacy and complexity of search and access pose a wealth of new research questions.

Objective
This interactive course will explore the latest research on algorithms and data structures for population scale genomics applications and give insights into both the technical basis as well as the domain questions motivating it.

Content
Over the duration of the semester, the course will cover three main topics. Each of the topics will consist of 70% lecture content and 30% practical content. Thereby, the practical implementation of the concepts presented in the lecture forms an integral part of the course.

1) Algorithms and data structures for the efficient compression of and search in texts and graphs. Motivated through applications in compressive genomics, the course will cover succinct indexing schemes for strings, trees and general graphs, compression schemes for binary matrices as well as the efficient representation of haplotypes and genomic variants.

2) Stochastic data structures and algorithms for approximate representation of strings and graphs as well as sets in general. This includes winnowing schemes and minimizers, sketching techniques, (minimal perfect) hashing, approximate membership query data structures, and approximate counting.

3) Data structures supporting encryption and data privacy. As an extension to data structures discussed in the earlier topics, this will include secure indexing using homomorphic encryption as well as design for secure storage and distribution of data.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered

Social Competencies
- Cooperation and Teamwork: fostered

Personal Competencies
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

Abstract
This course provides the basics of relational databases from the perspective of the user.

Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.
Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

- Lecture material (slides).


Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logic

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving fostered

Social Competencies
Communication fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking assessed

Abstract

Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

Objective

Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

Content

1. Introduction to microbiomes and microbial bioinformatics toolkit. Python, Pandas, Jupyter, GitHub, visualization libraries for Python.
3. Microbial diversity, function, and ecology. Molecular ecology, diversity metrics, ordination methods.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice

No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

All software used in the course is free and open-source.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered

Personal Competencies
Critical Thinking fostered
Self-direction and Self-management fostered

752-5500-00L Applied Bioinformatics: Microbiomes [W] 5 credits 2V+2U N. Bokulich, M. Ziemski

Abstract

Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

Objective

Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

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1. Introduction to microbiomes and microbial bioinformatics toolkit. Python, Pandas, Jupyter, GitHub, visualization libraries for Python.
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This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice

No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

All software used in the course is free and open-source.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered

Personal Competencies
Critical Thinking fostered
Self-direction and Self-management fostered

636-0554-00L Modelling and Simulation in Drug Development W 2 credits 3V H.-M. Kaltenbach
This course introduces how Modelling and Simulation (≈mathematical modelling) is applied today for the development of novel drugs in the pharmaceutical industry. Background lectures are combined with hands-on exercises on real-world examples.

The goal of this course is to provide students with a general understanding of drug development and pharmacology and how Modelling and Simulation is used to develop new drugs. Together with the application, the course will provide the background in the statistical methodologies used to model multivariate and time-dependent data with several levels of statistical variability.

Understanding the pharmacology, pharmacokinetics and pharmacodynamics (PK/PD) of novel drugs is key for a successful drug development process. Modelling and Simulation of these data is at the core to gain this understanding. Focusing on the application using real world examples, this course will introduce the statistical methodologies that have been developed to describe complex biological and pharmacological data with several levels of statistical variability.

The course will cover the basics of drug development and pharmacology with a focus on the principles of drug absorption, distribution, metabolism and excretion (ADME) and drug pharmacokinetics and pharmacodynamics (PK/PD). The different drug formats (small molecules, biologics, cell-based therapies, gene therapies and oligonucleotide formats) and their pharmacological properties will be introduced. The translation from animal to human to inform first-in human dose selections will be discussed.

The methodology part will cover compartmental PK/PD modelling, the practical aspects of numerical solutions of ordinary differential equation (ODEs) and the theory on non-linear mixed effects (NLME) modelling, which has become the de-facto standard methodology in the pharmaceutical industry. Practical problems of Modelling and Simulations will be discussed including parameter identifiability, model development and model evaluation and the application (or not) of the Occam’s Razor.

The course will focus on hands-on exercises using contemporary real-world examples from the pharmaceutical industry and provide necessary theoretical and methodological background in accompanying lectures.

The course is organized jointly by D-BSSE and LYO-X, a Quantitative Systems Pharmacology consulting company situated in Basel.

Basics of dynamic systems (e.g., BSSE courses by Iber or Kammash, or CSB course by Stelling).

Basics of statistics and R (e.g., BSSE courses by Kuipers or Kaltenbach).

The course is organized jointly by D-BSSE and LYO-X, a Quantitative Systems Pharmacology consulting company situated in Basel.

Basics of dynamic systems (e.g., BSSE courses by Iber or Kammash, or CSB course by Stelling).

Basics of statistics and R (e.g., BSSE courses by Kuipers or Kaltenbach).

Introduction to Machine Learning, Statistics/Probability, Programming in Python, Unix Command Line

From Publication to the Doctor’s Office

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

This seminar course is designed to provide students with an opportunity to review and critically evaluate recent publications in medical field focusing on examples when CS method or bioinformatics/statistical technique has lead to an instrumentation, technique or drug approved for clinical practice use.

Throughout the course, students will read and analyze recent publications that demonstrate successful applications and sometimes failures in medicine. Promising research applications will also be discussed. The publications will cover a wide range of topics, including drug discovery, image analysis, prognostic models, and learning healthcare.
The course will be structured as half lecture content and half seminar content. Lectures will review state of the medical practice prior to the discovery, obstacles in moving the field forward, and the need for improvement. Lecture will be followed by the seminar part where students will take turns presenting the assigned publications and leading the discussions. Students' presentations will focus on the main findings, and specific steps taken to translate the finding into clinical practice.

Publications will include examples of:
- specific CS/bioinformatics/statistics applications that has been brought to "bedside" – has been approved by European Medicines Agency / Food and Drug Administration (USA) for clinical use or are widely used in medical research;
- examples of failures of how a discovery did not translate into an endproduct and why;
- current active research areas.

Covered topics will include some of the following:
- Drug discovery: Computer-aided drug discovery has become an integral part of the drug development process, enabling researchers to design and screen large libraries of molecules in silico (i.e., using computer simulations) before synthesizing and testing them in the lab. This has led to the discovery of new drug candidates for a wide range of diseases, including cancer, Alzheimer's disease, and HIV/AIDS.
- Genomics: Advances in computational genomics have enabled researchers to analyze and interpret large-scale genomic data, including DNA sequencing data, to identify disease-causing mutations, genetic risk factors, and drug targets. Examples of the development of personalized medicine, where treatments are tailored to an individual's genetic makeup. Examples when drug target identified by genetics had led to approved treatment.
- Imaging: Computer vision and image processing techniques have revolutionized medical imaging, enabling researchers to extract quantitative information from medical images that were previously inaccessible. This has led to the development of new diagnostic and prognostic tools for a wide range of diseases, including cancer, cardiovascular disease, and neurological disorders.
- Real-world data applications: emulation of clinical trials using electronic health records data.
- Large language models: Generating clinical trial protocols using large language models. Natural Language Processing for information extraction and interpretation.
- Learning healthcare systems: Advances in data analytics and information technology have enabled the development of learning healthcare systems, which use real-time data from electronic health records, medical devices, and other sources to improve patient outcomes and reduce healthcare costs. This has the potential to transform the way healthcare is delivered, making it more personalized, efficient, and effective.

In addition to the presentations, students will also be required to write critical reviews of the assigned publications throughout the course. The reviews will be evaluated based on the students' ability to identify the strengths and weaknesses of the publications and to provide insightful and constructive feedback.

**Prerequisites / notice**
The course is intended for advanced undergraduate and graduate students with a background in computer science, bioinformatics, or a related field and interest in applying their skills to medical research.

This course assumes a working knowledge of R/Python and intermediate statistical analysis, including linear, logistic, survival regressions or ability and interest to learn them outside of the class.

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**Biology**

At least 10 ECTS need to be acquired in this category.

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<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, A. Hajnal, O. Voinnet, University lecturers</td>
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**Information for UZH students:**
Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

*Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree/courses/special-students/special-students-university-of-zurich.html*

**Abstract**
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping;forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**
This course focuses on the concepts of classical and modern genetics and genomics.

**Content**
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**
Scripts and additional material will be provided during the semester.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

551-0313-00L Microbiology (Part I) W 3 credits 2V W. D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad

Abstract
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes
Updated handouts will be provided during the class.

Literature
Current literature references will be provided during the lectures.

Prerequisites / notice
English

The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

551-0317-00L Immunology I W 3 credits 2V M. Kopf, A. Oxenius

Abstract
Introduction into structural and functional aspects of the immune system.

Objective
Introduction into structural and functional aspects of the immune system.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

636-0511-00L Developmental Neuroscience (University of Basel) W 2 credits 2V external organisers

Abstract
Development of cerebral cortex, hippocampus, motor system, olfactory system, visual system, auditory system, somatosensory system, navigation and memory systems, developmental disorders (autism, stem cells in the developing, adult and diseased brain.

636-0515-00L Molecular Medicine I (University of Basel) W 2 credits 2V external organisers

Abstract
This lecture series will introduce biologists to the mechanisms that cause human diseases. Emphasis will be on the genetic and environmental factors that lead to diseases, and how this knowledge can be used to develop diagnostic and therapeutic procedures.

262-6170-00L Molecular Mechanisms of Development (University of Basel) W 2 credits 2V external organisers
Molecular Control of Vertebrate Development and Organogenesis (University of Basel)  ■
The course must be registered for directly at Uni Basel. Uni Basel course number: 14459-01
Mind the enrolment deadlines at Uni Basel: https://www.unibas.ch/en/Studies/Mobility/Mobility-Switzerland/Students-Registering-From-Other-Swiss-Universities.html

Abstract
This lecture will present examples for developmental switches in a variety of systems, including single-cell organisms, plants, nematodes, flies and vertebrates. The lecture will illustrate a way of thinking rather than attempt to cover single details of the issues discussed.

Evolutionary Medicine: Morphological Changes and Pathologies (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: BIO440
Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
The course addresses aspects of this transdisciplinary research in lectures and provides opportunity to perform small research projects in the fields of paleogenetics, palaeopathology, imaging technologies, long- and short- term morphological changes.

New Approaches to Tackle Antibiotic Resistance (University of Basel)  ■
The course must be registered for directly at Uni Basel. Uni Basel course number: 14466-01
Mind the enrolment deadlines at Uni Basel: https://www.unibas.ch/en/Studies/Mobility/Mobility-Switzerland/Students-Registering-From-Other-Swiss-Universities.html

Abstract
This lecture series was redesigned in the scope of the recently established Swiss-wide research network on antibiotics called AntiResist. Internationally renowned scientists from different disciplines present their latest findings and discuss how their work relates to a better understanding of infection processes and antibiotic therapy.
Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.

Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.

We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

Subject-specific skills:
- Communication

Handout during the course.

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

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Handout during the course.
Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

262-6107-00L  Applied Mathematics and Informatics in Drug Discovery (University of Basel)  W  2 credits  2G  external organisers

The course must be registered for directly at Uni Basel.
Uni Basel course number: 55662-01

Mind the enrolment deadlines at Uni Basel:
https://www.unibas.ch/en/Studies/Mobility/Mobility-Switzerland/Students-Registering-From-Other-Swiss-Universities.html

Abstract
This introductory course will offer a practitioner’s review of mathematical concepts, informatics tools, and industrial approaches in relevant fields, especially bioinformatics, molecular modelling, cheminformatics, mathematical modelling, experiment design and statistical inference, and machine learning.

Objective
We explore the drug-discovery process and study applications of mathematics and informatics with case studies. We examine how mathematics concepts and informatics tools are used to model complex systems at multiple levels - molecular level, cellular and omics level, organ- and system-level, and population level - and how the multiscale modelling approach contributes to drug discovery.

529-0733-02L  Chemical Biology and Synthetic Biochemistry  W  6 credits  3G  K. Lang, M. Fottner

Abstract
Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

Objective
After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vitro - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.

Content
principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries)
directed evolution and protein engineering
chemical evolution of ubiquitin and targeted protein degradation

Lecture notes
A script will not be handed out. Handouts to the lecture will be provided through moodle.

Literature
Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Prerequisites / notice
Knowledge provided in the bachelor lectures ‘Nucleic Acids and Carbohydrates’ and ‘Proteins and Lipids’ is assumed for this lecture.

Lab Rotations
18 ECTS in total. (MSc CBB students starting after Autumn 2021 must register courses with course number 262-0*3*).
At least one lab rotation in different group/ supervisor than master’s thesis.
Further information and options: https://cbb.ethz.ch/studies/lab-rotations-internship.html

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<td>Abstract</td>
<td>Flexible short research project of 4 weeks, completed with a written report.</td>
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Flexible short research project of 6 weeks, completed with a written report. Students gain an overview of different research areas by applying concepts taught in the core courses and advanced courses.

Lab Rotation Long 1

9 credits

19A

Lecturers

Lab Rotation Long 2

9 credits

19A

Lecturers

Industry Internship

12 credits

26A

Lecturers

Industry internships of at least 8 weeks, completed with a written report. Students gain experience in an industrial environment and an overview of different research areas by applying concepts taught in the core courses and advanced courses.

The students look for a placement themselves.

Industry Internship Short

9 credits

17A

Supervisors

Industry internship of at least 6 weeks, completed with a written report. Students gain experience in an industrial environment and an overview of different research areas by applying concepts taught in the core courses and advanced courses.

The students look for a placement themselves.

Industry internship lasts for 6 weeks, longer duration will delay the completion of studies beyond two years. Recognition of the industry internship requires a meaningful 10-page report.

Industry Internship Long

18 credits

34A

Supervisors

Industry internship of at least 12 weeks, completed with a written report. Students gain experience in an industrial environment and an overview of different research areas by applying concepts taught in the core courses and advanced courses.

The students look for a placement themselves.

Industry internship lasts for 12 weeks, longer duration will delay the completion of studies beyond two years. Recognition of the industry internship requires a meaningful 10-page report.

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BSSE

Master’s Thesis

9 credits

17A

Supervisors

The Master Thesis is the result of an independent scientific research and/or constructive development project in the chosen area of specialization. The Master thesis concludes the Master programme. By writing up the Master thesis, students show their ability to independently produce a coherent and scientific piece of work.

The program concludes with a Master thesis that includes a written report and an oral presentation. The topic of the thesis can be chosen according to the student’s interests in the field of computational biology & bioinformatics.

The duration for the master's thesis in the study regulation 2017 (per Autumn Semester 2021) is 24 working weeks (thereof, 2 weeks are reserved for compensation of public holidays, sick leave and other unplanned short term absences.)

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional requirements.

Data Structures and Algorithms

8 credits

15R

F. Friedrich Wicker, M. Fischer

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract
This course is about fundamental algorithm design paradigms (such as induction, divide-and-conquer, backtracking, dynamic programming), classic algorithmic problems (such as sorting and searching), and data structures (such as lists, hashing, search trees). Moreover, an introduction to parallel programming is provided. The programming model of C++ will be discussed in some depth.

Objective
An understanding of the design and analysis of fundamental algorithms and data structures. Knowledge regarding chances, problems and limits of parallel and concurrent programming. Deeper insight into a modern programming model by means of the programming language C++.

Content
Data structures and algorithms: mathematical tools for the analysis of algorithms (asymptotic function growth, recurrence equations, recurrence trees), informal proofs of algorithm correctness (invariants and code transformation), design paradigms for the development of algorithms (induction, divide-and-conquer, sweep-line method, backtracking and dynamic programming), classical algorithmic problems (searching, selection and sorting), data structures for different purposes (linked lists, hash tables, balanced search trees, quad trees, heaps, union-find), further tools for runtime analysis (e.g. amortized analysis). The relationship and tight coupling between algorithms and data structures is illustrated with geometric problems (convex hull, line intersections, closest point pairs) graph algorithms (traversals, topological sort, transitive closure, shortest paths, minimum spanning trees, max flow).

Programming model of C++: correct and efficient memory handling, generic programming with templates, functional approaches with functors and lambda expressions.

Parallel programming: concepts of parallel programming (Amdahl's and Gustavson's laws, task/data parallelism, scheduling), problems of concurrency (data races, bad interleavings, memory reordering), process synchronisation and communication in a shared memory system (mutual exclusion, semaphores, monitors, condition variables), progress conditions (freedom from deadlock, starvation).

The concepts provided in the course are motivated and illustrated with practically relevant algorithms and applications.

Exercises are carried out in Code-Expert, an online IDE and exercise management system.

Literature
English lecture notes are available for the entire course.

Standard textbooks:

Prerequisites / notice
Lecture Series 252-0835-00L Informatik I or equivalent knowledge in programming with C++.

Please note that this is a self study (virtual) course, which implies that (in the autumn semester) there are no physical lectures or exercise sessions offered. If you want to attend the real course, please go to 252-0002-00L in the spring semester.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking fostered

252-0856-AAL Computer Science 4 credits E- F. Friedrich Wicker, R. Sasse
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

Objective
Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.

Content
The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

Lecture notes
Lecture slides and all other material will be made available for download on the course web page.

Literature
Bjarni Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed

Social Competencies
Communication fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

Stochastics (Probability and Statistics)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
From within the ETH, this book is freely available online under:

From within the ETH, this book is freely available online under:
http://www.springerlink.com/content/m17578/

Cell and Molecular Biology for Engineers I and II

Does not take place this semester.

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content
Lectures will include the following topics: DNA, chromosomes, RNA, protein, genetics, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytokatoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer, development and stem cells.

Literature
### Key for Hours

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**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Cyber Security Master

Field of Specialization

Core Courses

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<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>D. Basin, S. Krstic</td>
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Abstract

Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.

Objective

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems
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Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
     - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
     - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature

- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice

Prerequisite: Class on Information Security

252-1414-00L System Security  W  7 credits  2V+2U+2A  S. Capkun, S. Shinde

Abstract

The first part of the course covers general security concepts and hardware-based support for security.

In the second part, the focus is on system design and methodologies for building secure systems.

Objective

In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

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<th>Competencies</th>
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</table>

### Content

The course will cover topics spanning four broad themes with a focus on the first two themes:

1. Network defense mechanisms such as public-key infrastructures, TLS, VPs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. Network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. Analysis and inference topics such as traffic monitoring and network forensics; and

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

### Prerequisites / notice

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks course like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

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### Abstract

Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

### Objective

- Students are familiar with fundamental network-security concepts.
- Students can implement network-security protocols based on cryptographic libraries.
- Students can analyze and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students can implement network-security protocols based on cryptographic libraries.

### Content

The course will cover topics spanning four broad themes with a focus on the first two themes:

1. Network defense mechanisms such as public-key infrastructures, TLS, VPs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. Network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
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In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

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### Abstract

Privacy is a fundamental human right! And yet, technological advances (in particular in computer science) can often undermine privacy. In this class we will see how to formalize various notions of privacy and how to build systems that preserve privacy, by combining techniques from cryptography and statistics.

The later parts of the course will focus on applications to machine learning.

### Objective

- Reason about privacy concerns and the appropriate formalizations
- Combine tools from cryptography and statistics to build privacy mechanisms
- Assess, evaluate and prove privacy protection of a mechanism.

### Content

The first half of the course will cover topics from cryptography such as secure multiparty computation, zero-knowledge proofs, PIR, ORAM, anonymous communication, etc.

The second half will cover statistical notions of privacy, in particular differential privacy, and selected topics in machine learning privacy.

### Lecture notes

Lecture notes will be posted on Moodle.

### Literature

Boneh & Shoup - A Graduate Course in Applied Cryptography

References to relevant research papers will be provided.
Prerequisites / notice
Basic knowledge in cryptography, probability and machine learning is recommended but not required.

Electives

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<tr>
<th>Number</th>
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<td>227-0575-00L</td>
<td>Advanced Topics in Communication Networks</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>L. Vanbever</td>
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</tbody>
</table>

**Abstract**
This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall. Repetition for credit is possible with the consent of the instructor.

**Objective**
The goal of this course is to provide students with a deeper understanding of the existing and upcoming Internet technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments.

**Content**
In 2023, the course will cover advanced topics in communication networks such as:

- Advanced Internet routing (convergence, optimality, scalability, flexibility);
- Network programmability (OpenFlow, P4);
- Traffic engineering / Load Balancing;
- Network verification and synthesis;
- Network measurements;
- Network security;
- Upcoming transport protocols and technologies;
- Adaptive video streaming; and
- Network sustainability.

The course will be composed of lectures and practical exercises (some of which including labs).

**Lecture notes**
Lecture notes and material will be made available before each course on the course website.

**Literature**
Relevant references will be made available through the course website.

**Prerequisites / notice**
Prerequisites: Communication Networks (227-0120-00L) or equivalents / programming skills (in any language) are expected (some of the exercises will involve coding).

**Competencies**

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**Method-specific Competencies**

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**Hardware Security**

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<td>K. Razavi</td>
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**Abstract**
This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures and implementing some of these advanced attacks.

**Objective**
By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:

- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

**Literature**
Slides, relevant literature and manuals will be made available during the course.

**Prerequisites / notice**
Experience with Linux, low-level systems programming and computer architecture.

**Competencies**

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<td>Self-direction and Self-management</td>
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**Applied Security Laboratory**

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<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0811-00L</td>
<td>Applied Security Laboratory</td>
<td>W</td>
<td>8</td>
<td>7P</td>
<td>D. Basin</td>
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**Abstract**
Hands-on course on applied aspects of information security. Applied information security, operating system security, OS hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.

**Objective**
The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control, logging), application security with an emphasis on web applications (web server setup, common web exploits, authentication, session handling, code security), computer forensics, and risk analysis and risk management.
This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and carry out experiments in order to better understand the need for secure implementation and configuration of IT systems and to assess the effectivity and impact of security measures. This part is based on a book and virtual machines that include example applications, questions, and answers.

The students will also complete an independent project: based on a set of functional requirements, they will design and implement a prototypical IT system. In addition, they will conduct a thorough security analysis and devise appropriate security measures for their systems. Finally, they will carry out a technical and conceptual review of another system. All project work will be performed in teams and must be properly documented.

Lecture notes
The course is based on the book "Applied Information Security - A Hands-on Approach". More information:
http://www.infsec.ethz.ch/appliedlabbook

Literature
Recommended reading includes:
- Various: OWASP Guide to Building Secure Web Applications, available online
- O'Reilly, Loukides: Unix Power Tools, O'Reilly & Associates.
- Frisch: Essential System Administration, O'Reilly & Associates.
- NIST: Risk Management Guide for Information Technology Systems, available online as PDF
- BSI: IT-Grundschutzhandbuch, available online

Prerequisites / notice
* The lab allows flexible working since there are only few mandatory meetings during the semester.
* The lab covers a variety of different techniques. Thus, participating students should have a solid foundation in the following areas:
  - information security, operating system administration (especially Unix/Linux), and networking. Students are also expected to have a basic understanding of HTML, PHP, JavaScript, and MySQL because several examples are implemented in these languages.
  - Students must be prepared to spend more than three hours per week to complete the lab assignments and the project. This applies particularly to students who do not meet the requirements given above. Successful participants of the course receive 8 credits as compensation for their effort.
* All participants must sign the lab's charter and usage policy during the introduction lecture.

252-1411-00L Security of Wireless Networks W 6 credits 2V+1U+2A S. Capkun, K. Kostiainen
Abstract
This course discusses physical layer aspects of wireless communication and a wide range of security-related topics in the domain of wireless technologies. It mainly targets computer science students. Though useful, a background in signal processing or physical layer concepts is not required. A basic understanding of security (e.g. as taught in 252-0211.00L Information Security) is recommended.
Objective
After this course, students should be able to describe and classify security goals of and attacks on various wireless networks and technologies, with an emphasis on physical layer aspects.
Content
- Introduction to wireless communication
- Physical layer security schemes
- Spreading techniques and their application in jamming-resilient communication and Global Navigation Satellite Systems (GNSSs)
- Secure ranging with Ultra-Wide Band (UWB)
- Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)

263-4657-00L Advanced Encryption Schemes W 5 credits 2V+1U+1A to be announced
Does not take place this semester.
Abstract
Public-Key Encryption has had a significant impact by enabling remote parties to communicate securely via an insecure channel. Latest schemes go further by providing a fine-grained access to the encrypted data.
Objective
The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.
Content
We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

263-4665-00L Zero-Knowledge Proofs W 5 credits 2V+1U+1A J. Bootle
Abstract
Zero-knowledge proofs are protocols which allow a prover to convince a verifier that a statement is true without leaking any information beyond that fact. This course is a detailed introduction to zero-knowledge proof protocols.
Objective
- To understand what it means for a zero-knowledge proof to be secure
- To construct and analyse various types of zero-knowledge proofs
- To understand some applications of zero-knowledge proofs

2024 Autumn Semester

Seminar

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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</table>

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 614 of 2667
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract

The seminar covers various topics in information security: security protocols (models, specification & verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, key-management for sensor networks.

Objective

The main goals of the seminar are the independent study of scientific literature and assessment of its contributions as well as learning and practicing presentation techniques.

Content

The seminar covers various topics in information security, including network security, cryptography and security protocols. The participants are expected to read a scientific paper and present it in a 35-40 min talk. At the beginning of the semester a short introduction to presentation techniques will be given.

Selected Topics

- security protocols: models, specification & verification
- trust management, access control and non-interference
- side-channel attacks
- identity-based cryptography
- host-based attack detection
- anomaly detection in backbone networks
- key-management for sensor networks

Literature

The reading list will be published on the course web site.

### Semester Project

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>260-0100-00L</td>
<td>Semester Project</td>
<td>W</td>
<td>12 credits</td>
<td>26A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract

The Semester Project provides students with the opportunity to apply acquired knowledge and skills.

Objective

The students can gain hand-on experience by solving independently a technical-scientific problem.

### Minor

#### Data Management Systems

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>263-3010-00L</td>
<td>Big Data</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>G. Fourny</td>
</tr>
</tbody>
</table>

Abstract

Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</table>

263-3845-00L Data Management Systems W 8 credits 3V+1U+3A G. Alonso

Abstract

The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Objective

The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content

The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Literature

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.
Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>C. Cotri Jimenez</td>
</tr>
<tr>
<td>Abstract</td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.</td>
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<tr>
<td>Objective</td>
<td>Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.</td>
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<tr>
<td>Content</td>
<td>The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
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<tr>
<td>Topics covered in the lecture include:</td>
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<tr>
<td>Fundamentals:</td>
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<tr>
<td>What is data?</td>
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<td>Bayesian Learning</td>
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<td>Computational learning theory</td>
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<td>Supervised learning:</td>
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<tr>
<td>Ensembles: Bagging and Boosting</td>
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<td>Max Margin methods</td>
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<tr>
<td>Neural networks</td>
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<td>Unsupervised learning:</td>
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<tr>
<td>Dimensionality reduction techniques</td>
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<td>Clustering</td>
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<td>Mixture Models</td>
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<td>Non-parametric density estimation</td>
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<tr>
<td>Learning Dynamical Systems</td>
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<tr>
<td>Lecture notes</td>
<td>No lecture notes, but slides will be made available on the course webpage.</td>
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252-1414-00L System Security W 7 credits 2V+2U+2A S. Capkun, S. Shinde

Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-2800-00L Design of Parallel and High-Performance Computing W 9 credits 2V+2U+4A T. Hoefler

Abstract
Advanced topics in parallel and high-performance computing.
Objective

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3210-00L Deep Learning

W 8 credits 3V+2U+2A T. Hofmann

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/ml2/

  Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/

  Introduction to Machine Learning
  https://las.inf.ethz.ch/teaching/introml-2019

  Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/slt/

  Computational Statistics
  https://stat.ethz.ch/lectures/ss19/comp-stats.php

  Probabilistic Artificial Intelligence
  https://las.inf.ethz.ch/teaching/pai-f18

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.
Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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**Deep Learning**

**W 8 credits**

3V+2U+2A  T. Hofmann

**Abstract**

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

**Prerequisites / notice**

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://mi2.in.tum.de/courses/sl/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

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**Probabilistic Artificial Intelligence**

**W 8 credits**

3V+2U+2A  A. Krause

**Abstract**

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

**Content**

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bands and Bayesian optimization
- Reinforcement learning

**Prerequisites / notice**

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning” is considered as a prerequisite.

**Competencies**

- Subject-specific Competencies: assessed
- Method-specific Competencies: assessed
- Social Competencies: fostered
- Personal Competencies: assessed

**Elective Courses**

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<tr>
<th>Number</th>
<th>Title</th>
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</tr>
</thead>
<tbody>
<tr>
<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>W</td>
<td>6</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
</tr>
</tbody>
</table>
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

The course is split into 4 parts:

---

**Robustness of Machine Learning**

- Adversarial attacks and defenses on deep learning models.
- Certified training of deep neural networks (combining symbolic and continuous methods).

**Privacy of Machine Learning**

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across vision, natural language and tabular data).
- Differential privacy for defending machine learning.
- AI Regulations and checking model compliance.

**Fairness of Machine Learning**

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness (for both vision and tabular data).
- Enforcing group fairness (e.g., demographic parity, equalized odds).

**Robustness, Privacy and Fairness of Foundation Models**

- We discuss all previous topics, as well as programmability, in the context of latest foundation models (e.g., LLMs).


The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

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**252-3005-00L Natural Language Processing**

Objective

The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content

This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

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**263-5005-00L Artificial Intelligence in Education**

Abstract

Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.

Objective

The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.

Content

The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture notes

Lecture slides will be made available at the course Web site.

Lecture notes

No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

Prerequisites / notice

There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.
3V+1U+2A
assessed

Concepts and Theories
Introduction to GNN concepts: 1) problem-solving on graphs (node-, edge-, graph-level objectives), structural priors (inductive biases) of graph data, applications for graph learning. 2) Graph Neural Networks: convolutional, attentional, message passing; overview on the zoo of published operators. Relations to Transformers and DeepSets. 3) Expressivity of GNNs. 4) Scalability of Graph Neural Networks.

Prerequisites / notice
263-3210-00 Depp Learning or 263-0008-00 Computational Intelligence Lab.
252-0220-00 Introduction to Machine Learning; Statistics-Probability; Programming in Python; Unix Command Line.

Objective
Many established deep learning methods require dense input data with a well-defined structure (e.g. an image, a sequence of word embeddings). However, many practical applications deal with sparsely connected and complex data structures, such as molecules, knowledge graphs or social networks. Graph Neural Networks (GNNs) and general representation learning on graphs have recently experienced a surge in popularity because it addresses the challenge to effectively learn representations over said structures. In this course, we aim to understand the fundamental principles of deep (representation) learning on graphs, the similarities and differences to other concepts in deep learning, as well as the unique challenges from a practical point of view. Finally, we provide an overview of recent applications of graph neural networks.

Content
Introduction to GNN concepts: 1) problem-solving on graphs (node-, edge-, graph-level objectives), structural priors (inductive biases) of graph data, applications for graph learning. 2) Graph Neural Networks: convolutional, attentional, message passing; overview on the zoo of published operators. Relations to Transformers and DeepSets. 3) Expressivity of GNNs. 4) Scalability of Graph Neural Networks.

Prerequisites / notice
263-3210-00 Depp Learning or 263-0008-00 Computational Intelligence Lab.
252-0220-00 Introduction to Machine Learning; Statistics-Probability; Programming in Python; Unix Command Line.

Objective
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Content
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

Prerequisites / notice
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Competencies
Subject-specific Competencies assessed
Concepts and Theories
Method-specific Competencies assessed
Analytical Competencies
Problem-solving
Social Competencies assessed
Communication
Cooperation and Teamwork
Personal Competencies assessed
Creative Thinking
Critical Thinking

Objective
The machine course reviews solutions provided by machine learning to the most challenging questions in human genomics.

Content
Over the last few years, the parallel development of machine learning methods and molecular profiling technologies for human cells, such as sequencing, created an extremely powerful tool to get insights into the cellular mechanisms in healthy and diseased contexts. In this course, we will discuss the state-of-the-art machine learning methodology solving or attempting to solve common problems in human genomics. At the end of the course, you will be familiar with (1) classical and advanced machine learning architectures used in genomics, (2) bioinformatics analysis of human genomic and transcriptomic data, and (3) data types used in this field.

Prerequisites / notice
Introduction to Machine Learning, Statistics-Probability, Programming in Python, Unix Command Line

Competencies
Subject-specific Competencies fostered
Concepts and Theories
Techniques and Technologies fostered
Social Competencies assessed
Communication
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve these.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

### Theoretical Computer Science

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
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</table>

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals: What is data?
- Bayesian Learning
- Computational learning theory

- Supervised learning: Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

- Unsupervised learning: Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

No lecture notes, but slides will be made available on the course webpage.


The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains.

In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

The Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

No lecture notes, but slides will be made available on the course webpage.

B. Gärtner, M. Hoffmann, P. Schnider, to be announced
Subject-specific Competencies
Structural graph theory forms, besides extremal graph theory, one of the two main pillars of modern graph theory. While the latter is concerned with maximizing the number of edges or the density of graphs, structural graph theory focuses on understanding the structural nature of all members of a class of graphs. This course will cover several cornerstone results of structural graph theory.

Objective
The students obtain a thorough understanding of the mathematical tools, techniques and results in structural graph theory, and understand the relations and applications which this rich theory has in other areas, such as computational complexity and logic. Additionally, they enhance their skillset for the design of efficient algorithms on structurally constrained classes of graphs.

Content
Graph minors: Connectivity and versions of Menger's theorem, Planar graphs, Wagner's theorem, Tree-width, algorithmic applications of tree-width and Courcelle's theorem, balanced separators and Alon-Seymour-Thomas theorem, Grid Minor Theorem, Erdős–Pósa property and algorithmic applications, Graph Minor Structure Theorem, Membership complexity, Wagner's conjecture

The students obtain a thorough understanding of the mathematical tools, techniques and results in structural graph theory, and understand the relations and applications which this rich theory has in other areas, such as computational complexity and logic. Additionally, they enhance their skillset for the design of efficient algorithms on structurally constrained classes of graphs.

Method-specific Competencies

E. Steiner, A. Tognetti, Topics in Graph Theory, Springer, 2011.

Literature

Information Theory I

263-4500-00L Advanced Algorithms

Abstract
This is a graduate-level course on algorithm design (and analysis). It covers a range of topics and techniques in approximation algorithms, sketching and streaming algorithms, and online algorithms.

Objective
This course familiarizes the students with some of the main tools and techniques in modern subareas of algorithm design.

Content
The lectures will cover modern topics in algorithm design and analysis, including the following: graph sparsifications while preserving cuts or distances, various approximation algorithms techniques and concepts, metric embeddings and probabilistic tree embeddings, online algorithms, multiplicative weight updates, streaming algorithms, sketching algorithms.

Lecture notes
https://people.inf.ethz.ch/~aroeyskoe/AA23

Prerequisites / notice
Sufficient comfort with both (A) Algorithm Design & Analysis and (B) Probability & Concentrations. E.g., having passed the course Algorithms, Probability, and Computing (APC) is recommended, though not required formally. If you are not sure whether you are ready for this class or not, please consult the instructor.

Competencies

263-4513-00L Structural Graph Theory

Abstract
Structural graph theory forms, besides extremal graph theory, one of the two main pillars of modern graph theory. While the latter is concerned with maximizing the number of edges or the density of graphs, structural graph theory focuses on understanding the structural nature of all members of a class of graphs. This course will cover several cornerstone results of structural graph theory.

Objective
The students obtain a thorough understanding of the mathematical tools, techniques and results in structural graph theory, and understand the relations and applications which this rich theory has in other areas, such as computational complexity and logic. Additionally, they enhance their skillset for the design of efficient algorithms on structurally constrained classes of graphs.

Content
Graph minors: Connectivity and versions of Menger's theorem, Planar graphs, Wagner's theorem, Tree-width, algorithmic applications of tree-width and Courcelle's theorem, balanced separators and Alon-Seymour-Thomas theorem, Grid Minor Theorem, Erdős–Pósa property and algorithmic applications, Graph Minor Structure Theorem, Membership complexity, Wagner's conjecture

Perfect graphs: Introduction to graph coloring and definition, Proof of the weak perfect graph theorem, Strong perfect graph theorem

Lecture notes
Will be provided well before the start of the HS.

Literature
Topics in Structural Graph Theory (Lowell W. Beineke, Robin J. Wilson) (Remark: Not a perfect fit for this course, but there is substantial overlap on some of the topics).

Prerequisites / notice
The students should be familiar with the basics of the following areas: graph theory, linear programming, complexity theory and probabilistic methods. Having taken a previous course covering basic graph theory is strongly advised.

Competencies

Projects in Topological Data Analysis

Abstract
This seminar complements the course "Introduction to Topological Data Analysis". Students of the seminar will collaborate with students from international universities on concrete projects in topological data analysis, both theoretical and applied.

Objective
Each student is expected to collaborate in an international working group with students from the partner universities. Each group works on one of the projects suggested by the lecturers, and is assigned a mentor. At the end of the semester, each working group presents their findings in a written report and an oral presentation.

Content
This seminar complements the course Introduction to Topological Data Analysis. Students get to apply what they learned in the introductory course to concrete projects in the area of topological data analysis. These projects can be of theoretical nature, e.g., the design and analysis of a new algorithm, or applied, such as using methods from topological data analysis on concrete data sets.

Prerequisites / notice
Successful participation in the course "Introduction to Topological Data Analysis" or equivalent background in topological data analysis is required.

Competencies

Method-specific Competencies

Analytical Competencies

Decision-making

Problem-solving

T. M. Cover and J. Thomas, Elements of Information Theory (second edition)
J. Lengler
A. Lapidoth
R. M. Steiner

Prerequisites / notice
Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Seminar-, Bachelor- and Master Thesis projects in the area.
### 263-5300-00L

**Guarantees for Machine Learning**  
*A. Foster, F. Yang*
*W 7 credits 3V+1U+2A*

**Abstract**
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**
By the end of the semester students should be able to:

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work.

- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions.

- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in individual exercises, homeworks and potentially in the final project.

- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

**Content**
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

**Prerequisites / notice**
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

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### 401-3055-64L

**Algebraic Methods in Combinatorics**  
*W 5 credits 2V+1U*

**Abstract**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

**Content**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to a linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

**Prerequisites / notice**

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at [https://moodle-app2.let.ethz.ch/course/view.php?id=15757](https://moodle-app2.let.ethz.ch/course/view.php?id=15757)
401-3901-00L Linear & Combinatorial Optimization W 10 credits 4V+2U R. Zenklusen

Objective
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature

Competencies
- Concepts and Theories
- Techniques and Technologies

402-0448-01L Quantum Information Processing I: Concepts W 5 credits 2V+1U J. Renes

Abstract
This theory part QIP I together with the experimental part 402-0448-02L QIP II (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in Physics.

Objective
The course covers the key concepts and formalism of quantum information processing. Topics include quantum algorithms, quantum error correction, quantum cryptography, and quantum metrology, with an emphasis on the power of quantum information processing beyond that of classical information processing. The formalism of quantum states, measurements, and channels is developed in detail.

Content
The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum circuits, quantum algorithms (Shor, Grover, Deutsch-Josza,..), stabilizer-based quantum error correction, fault-tolerant designs, the BB84 quantum key distribution protocol, and simple methods of quantum metrology.

Literature
- Quantum Computation and Quantum Information
  Michael Nielsen and Isaac Chuang
  Cambridge University Press

Competencies
- Concepts and Theories
- Techniques and Technologies

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**Visual and Interactive Computing**

**Core Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>252-0543-01L</td>
<td>Computer Graphics</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>M. Gross, M. Papas</td>
</tr>
</tbody>
</table>

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 625 of 2667
Content

We will begin with an introduction to light emission and radiometric quantities, followed by an exploration of geometry representations and texture mapping.

Next, we will mathematically formulate the physics of light transport and appearance modeling.

Subsequently, we will introduce relevant concepts from Monte Carlo integration and develop path-tracing algorithms to solve these equations by simulating light transport for direct and global illumination due to hard surfaces and participating media, such as fog, smoke, and translucent objects.

Moreover, we will present techniques for significantly improving path-tracing efficiency, including importance sampling, multiple importance sampling, stratified sampling, denoising, and acceleration data structures.

The course lectures will conclude with an overview of image-based capture and rendering methods. Topics covered will include geometry reconstruction, material acquisition, differentiable rendering, and image-based rendering.

Lecture notes

no

Literature

Books:
Physically Based Rendering: From Theory to Implementation
High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
Multiple view geometry in Computer Vision

Prerequisites / notice

Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, and the Visual Computing course are recommended.

The programming assignments will be in C++. This will not be taught in the class.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies

Communication fostered
Cooperation and Teamwork assessed
Leadership and Responsibility fostered

Personal Competencies

Creative Thinking assessed
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

Objective

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

Elective Courses

Number Title Type ECTS Hours Lecturers
227-0560-00L Computer Vision and Artificial Intelligence for Autonomous Cars Up until FS2022 offered as Deep Learning for Autonomous Driving W 6 credits 3V+2P C. Sakaridis

Abstract

This course introduces the core computer vision techniques and algorithms that autonomous cars use to perceive the semantics and geometry of their driving environment, localize themselves in it, and predict its dynamic evolution. Emphasis is placed on techniques tailored for real-world settings, such as multi-modal fusion, domain-adaptive and outlier-aware architectures, and multi-agent methods.

Objective

Students will learn about the fundamentals of autonomous cars and of the computer vision models and methods these cars use to analyze their environment and navigate themselves in it. Students will be presented with state-of-the-art representations and algorithms for semantic, geometric and temporal visual reasoning in automated driving and will gain hands-on experience in developing computer vision algorithms and architectures for solving such tasks.

After completing this course, students will be able to:
1. understand the operating principles of visual sensors in autonomous cars
2. differentiate between the core architectural paradigms and components of modern visual perception models and describe their logic and the role of their parameters
3. systematically categorize the main visual tasks related to automated driving and understand the primary representations and algorithms which are used for solving them
4. critically analyze and evaluate current research in the area of computer vision for autonomous cars
5. practically reproduce state-of-the-art computer vision methods in automated driving
6. independently develop new models for visual perception
The content of the lectures consists in the following topics:

1. Fundamentals
   (a) Fundamentals of autonomous cars and their visual sensors
   (b) Fundamentals of mixed reality and the algorithms for autonomous cars

2. Semantic perception
   (a) Semantic segmentation
   (b) Object detection
   (c) Domain-adaptive and outlier-aware semantic perception

3. Geometric perception and localization
   (a) Depth estimation
   (b) 3D reconstruction
   (c) Visual localization
   (d) Unimodal visual/lidar 3D object detection

4. Robust perception: multi-modal, multi-domain and multi-agent methods
   (a) Multi-modal 2D and 3D object detection
   (b) Visual grounding and verbo-visual fusion
   (c) Domain-adaptive and outlier-aware semantic perception
   (d) Vehicle-to-vehicle communication for perception

5. Temporal perception
   (a) Multiple object tracking
   (b) Motion prediction

The practical projects involve implementing complex computer vision architectures and algorithms and applying them to real-world, multi-modal driving datasets. In particular, students will develop models and algorithms for:

1. Semantic segmentation and depth estimation
2. Sensor calibration for multi-modal 3D driving datasets
3. 3D object detection using lidars

Lecture notes
Lecture slides are provided in PDF format.

Prerequisites / notice
Students are expected to have a solid basic knowledge of linear algebra, multivariate calculus, and probability theory, and a basic background in computer vision and machine learning. All practical projects will require solid background in programming and will be based on Python and libraries of it such as PyTorch.

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<tr>
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<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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252-0546-00L Physically-Based Simulation in Computer Graphics W 5 credits 2V+1U+1A S. Coros, B. Thomaszewski

Abstract
This lecture provides an introduction to physically-based simulation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Objective
This lecture provides an introduction to physically-based simulation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Content
The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

Prerequisites / notice
Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

263-5905-00L Mixed Reality W 5 credits 3G+1A Z. Bauer, C. Holz, M. Pollefeys

Abstract
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

Objective
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

Content
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:
Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course is student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice
Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

**Interfocus Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-0006-00L</td>
<td>Algorithms Lab</td>
<td>W</td>
<td>8</td>
<td>4P+3A</td>
<td>A. Steger</td>
</tr>
</tbody>
</table>
Abstract

Students learn how to solve algorithmic problems given by a textual description (understanding problem setting, finding appropriate modeling, choosing suitable algorithms, and implementing them). Knowledge of basic algorithms and data structures is assumed; more advanced material and usage of standard libraries for combinatorial algorithms are introduced in tutorials.

Objective

The objective of this course is to learn how to solve algorithmic problems given by a textual description. This includes appropriate problem modeling, choice of suitable (combinatorial) algorithms, and implementing them (using C/C++, STL, CGAL, and BGL).

Literature


263-0009-00L Information Security Lab

W 8 credits 2V+1U+3P+1A S. Shinde, D. Basin, S. Capkun, K. Paterson

Abstract

This InterFocus Course will provide a broad, hands-on introduction to Information Security, introducing adversarial thinking and security by design as key approaches to building secure systems.

Objective

This course will introduce key concepts from Information Security, both from attack and defence perspectives. Students will gain an appreciation of the complexity and challenge of building secure systems.

Content

The course is organised in three-week segments. In each segment, a new concept from Information Security will be introduced. The overall scope will be broad, including cryptography, protocol design, system security, and privacy.

Lecture notes

Will be made available during the semester.

Literature

Paul C. van Oorschot, Computer Security and the Internet: Tools and Jewels.
Dan Boneh and Victor Shoup, A Graduate Course in Applied Cryptography.

Prerequisites / notice

Ideally, students will have taken the D-INFK Bachelors course "Information Security" or an equivalent course at Bachelors level.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Personal Competencies
- Adaptability and Flexibility fostered

Free Electives

Students can individually chose from the entire Master course offerings in the area of Computer Science (or a closely related field), from ETH Zurich, EPF Lausanne, the University of Zurich and - but only with the consent of the Director of Studies - from all other Swiss universities.

Course Catalogue of ETH Zurich

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-INFK

Internship

Number Title Type ECTS Hours Lecturers
260-0700-00L Internship E- 0 credits external organisers

Abstract

An internship provides opportunities to gain experience in an industrial environment and it creates a network of contacts.

Objective

see above

Master’s Thesis

Number Title Type ECTS Hours Lecturers
260-0800-00L Master’s Thesis O 30 credits 64D Supervisors

Abstract

Only students who fulfill the following criteria are allowed to begin with their master thesis:

- successful completion of the bachelor programme;
- fulfilling of any additional requirements necessary to gain admission to the master programme.

The Master’s thesis concludes the study program and demonstrates the students’ ability to use the knowledge and skills acquired during Master’s studies to solve a complex cyber security problem.

Objective

To work independently and to produce a scientifically structured work.

Cyber Security Master - Key for Type

| W | Eligible for credits | Dr | Suitable for doctorate |
| E- | Recommended, not eligible for credits | O | Compulsory |
| Z | Courses outside the curriculum | W+ | Eligible for credits and recommended |

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium | | |

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 628 of 2667
## DAS in Applied Statistics

### Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>447-0649-01L</td>
<td>Applied Statistical Regression I</td>
<td>O</td>
<td>4</td>
<td>1V+1U</td>
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<td>Does not take this semester.</td>
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<td><strong>Abstract</strong></td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Understanding the concept and flexibility of generalized linear models and correct interpretation of the corresponding model outputs.</td>
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<tr>
<td>447-0649-02L</td>
<td>Applied Statistical Regression II</td>
<td>O</td>
<td>2</td>
<td>1V+1U</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Generalized linear models (GLMs) and basic ideas of more advanced regression models.</td>
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<td><strong>Objective</strong></td>
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<tr>
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<td>Understanding the concept and flexibility of generalized linear models and correct interpretation of the corresponding model outputs.</td>
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<tr>
<td>447-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design I</td>
<td>O</td>
<td>3</td>
<td>1V+1U</td>
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<td>Does not take this semester.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Decision-making</td>
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<td>Personal Competencies</td>
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<td>Critical Thinking</td>
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### Electives

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<th>Lecturers</th>
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<tr>
<td>447-0625-02L</td>
<td>Applied Analysis of Variance and Experimental Design II</td>
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<td>3</td>
<td>1V+1U</td>
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<tr>
<td></td>
<td>Does not take this semester.</td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>Random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<td><strong>Objective</strong></td>
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<td>Participants will be able to plan and analyze sophisticated experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<td></td>
<td>Creative Thinking</td>
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</table>

| 447-0621-00L | Nonparametric Regression                   | W | 1 | 1G | M. Mächler |
|             | Does not take this semester.               |      |      |           |           |
|             | **Abstract**                               |      |      |           |           |
|             | This course focusses on nonparametric estimation of probability densities and regression functions. These recent methods allow modelling without restrictive assumptions such as 'linear function'. These smoothing methods require a weight function and a smoothing parameter. Focus is on one dimension, higher dimensions and samples of curves are treated briefly. Exercises at the computer. | | | | |
|             | **Objective**                              |      |      |           |           |
|             | Knowledge on estimation of probability densities and regression functions via various statistical methods. Understanding of the choice of weight function and of the smoothing parameter, also done automatically. Practical application on data sets at the computer. | | | | |

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**Autumn Semester 2024**  
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447-6257-00L Repeated Measures ■ W 1 credit 1G M. L. Spohn
Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

Objective Generation and structure of repeated measures. Planning and realization of corresponding studies. Within- and between-subjects factors.

Competencies Subject-specific Competencies Concepts and Theories assessed
- Analytical Competencies assessed
- Media and Digital Technologies assessed
- Problem-solving assessed

Personal Competencies Creative Thinking assessed

447-6289-00L Sampling Surveys ■ W 2 credits 1G T. Schoch
Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

Objective Participants will gain the ability of recognizing repeated measures and to analyze them adequately. They will know how to deal with pseudoreplicates.

Competencies Subject-specific Competencies Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Decision-making assessed

447-6265-00L Deep Learning: A Probabilistic Approach ■ Does not take place this semester.

Objective This course introduces probabilistic deep learning (DL). DL is used for data with complex features like images. We treat DL as probabilistic models, as a continuation of GLMs (logistic regression, ...). The models are fitted with maximum likelihood or Bayesian learning.

Content You will learn about different neural network architectures (e.g. fully connected and convolutional neural networks) and how to choose the appropriate NN architecture for your task at hand.

Literature "Bayes Rules! An Introduction to Applied Bayesian Modeling", Alicia A. Johnson, Miles Q. Ott, Mine Dogucu - CRC Press 2022

Prerequisites / notice - applied regression
- R

447-6273-00L Applied Bayesian Statistics ■ W 2 credits 2G S. Robert
Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

Objective You will get practical experiences in setting up probabilistic DL models, learn how to tune them, and learn how to control the training procedure.

Content We will learn how to describe business/scientific problems as probabilistic models, apply Bayes rules to draw inference from data, and use the probabilistic programming language STAN to obtain samples from posterior distributions. We will learn how to build, fit and validate Bayesian models of increasing complexity. There will be examples of applications from various fields: insurance, meteorology, marketing, etc.

Literature - introductory statistics
- applied regression
- R
## Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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</tbody>
</table>

## 447-6191-00L Statistical Analysis of Financial Data

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

### Abstract


### Objective

Getting to know the typical properties of financial data and appropriate statistical models, incl. the corresponding functions in R.

## 447-6255-00L Analysis of High-Dimensional Data

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

### Abstract

Block course on analysis of high-dimensional data with a focus on prediction and feature assessment.

### Objective

The goal of this course is to gain a good understanding of the concepts discussed during the lecture and to apply the new methods on real data examples using the software "R". The topics covered in the lecture are:

1. Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization
2. Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

### Content

Course on Analysis of High-Dimensional Data with focus on Prediction and Feature Assessment.

1. Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization
2. Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

### Literature


### Prerequisites / notice

The exercises are done exclusively with the (free, open source) software "R" ([http://www.r-project.org](http://www.r-project.org)). A final exam will also happen at the computers, using R (and your brains!).

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Project Management</td>
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<td>Cooperation and Teamwork</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Self-direction and Self-management</td>
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</table>

## 447-6233-00L Spatial Statistics

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

### Abstract

The block course is based on lecture notes ([https://bookdown.org/staedler_n/highdimstats/](https://bookdown.org/staedler_n/highdimstats/)).

### Objective

The exercises are done exclusively with the (free, open source) software "R" ([http://www.r-project.org](http://www.r-project.org)). A final exam will also happen at the computers, using R (and your brains!).

### Competencies

<table>
<thead>
<tr>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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</tbody>
</table>
Abstract
In many research fields, spatially referenced data are collected. When analysing such data the focus is either on exploring their structure (dependence on explanatory variables, autocorrelation) and/or on spatial prediction. The course provides an introduction to geostatistical methods that are useful for such purposes.

Objective
The course will provide an overview of the basic concepts and stochastic models that are commonly used to model geostatistical data sets. In addition, the participants will learn a number of geostatistical techniques and acquire some familiarity with software that is useful for analysing spatial data.

Content
After an introductory discussion of the types of problems and the kind of data that arise in environmental research, an introduction into linear geostatistics (models: stationary random processes, modelling large-scale spatial patterns by regression, modelling autocorrelation by variogram; kriging: mean-square prediction of spatial data) will be taught. The lectures will be complemented by data analyses that the participants have to do themselves.

Lecture notes
Slides, descriptions of the problems for the data analyses and worked-out solutions to them will be provided.

Literature

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>assessed</td>
<td>fostered</td>
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<td>Techniques and Technologies</td>
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<td>fostered</td>
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<tr>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>fostered</td>
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<tr>
<td>Modeling</td>
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<td>Media and Digital Technologies</td>
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<tr>
<td>Autocorrelation</td>
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<td>Problem-solving</td>
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<tr>
<td>Kriging</td>
<td></td>
<td>Project Management</td>
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<tr>
<td>Linear regression</td>
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<td>Communication</td>
<td>fostered</td>
<td>fostering</td>
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<tr>
<td>Autocorrelation by variogram</td>
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<td>Cooperation and Teamwork</td>
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<td>Large-scale spatial patterns</td>
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<td>Customer Orientation</td>
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<td>fostered</td>
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<td>Regression</td>
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<td>Leadership and Responsibility</td>
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<td>fostered</td>
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<td>Sensitivity to Diversity</td>
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<td>Adaptability and Flexibility</td>
<td>fostered</td>
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Diploma Thesis

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-1990-00L</td>
<td>Diploma Thesis</td>
<td>O</td>
<td>2</td>
<td>4D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
The diploma thesis typically consists of a data analysis of data from a participant's own field of work. The thesis requires a time expenditure of about one or two weeks. Thesis work should prove the participants' capability to apply useful and modern statistical methods to address appropriate questions properly and effectively.

Objective
Thesis work should prove the participants' capability to apply useful and modern statistical methods to address appropriate questions properly and effectively.

DAS in Applied Statistics - Key for Type

<table>
<thead>
<tr>
<th>W</th>
<th>Eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
</tbody>
</table>

Key for Hours

| V    | lecture         |
| G    | lecture with exercise |
| U    | exercise        |
| S    | seminar         |
| K    | colloquium      |

Key for Hours

P practical/laboratory course
A independent project
D diploma thesis
R revision course / private study

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Adaptability and Flexibility

Subject-specific Competencies

2V+2U+2A assessed

The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.

Objective

In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content

The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered

Social Competencies

Communication fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered

ECTS

2V+2U+2A

S. Capkun, S. Shinde

Introduction to Information Security

268-0101-00L

Objective

In this course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students' understanding of the theory parts.

Graduates of the course know the technical foundations of information security and understand the difficulty and complexity involved when trying to build secure systems.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 633 of 2667
In this new course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students’ understanding of the theory parts.

### Competencies

**Subject-specific Competencies**
- Concepts and Theories (assessed)
- Techniques and Technologies (assessed)

**Method-specific Competencies**
- Analytical Competencies (fostered)
- Decision-making (fostered)
- Media and Digital Technologies (fostered)
- Problem-solving (fostered)

### Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0463-00L</td>
<td>Security Engineering</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>D. Basin, S. Krstic</td>
</tr>
</tbody>
</table>

**Abstract**
Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.

**Objective**
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include:

- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include
- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems

Modules taught:
1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security
Content
- Introduction to wireless communication
- Physical layer security schemes
- Spreading techniques and their application in jamming-resilient communication and Global Navigation Satellite Systems (GNSSs)
- Secure ranging with Ultra-Wide Band (UWB)
- Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Problem-solving

Method-specific Competencies
- Cooperation and Teamwork

Personal Competencies
- Critical Thinking

268-0201-00L Information Security Seminar and Project
W 2 credits 2S S. Matetic

Abstract
Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.

Objective
Participants have understood and presented a publication or report on a present topic in information security. By attending other participants presentations students get further introduced to additional current information security related topics/incidents.

Content
Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.

268-0202-00L Contemporary Topics in Cyber Security
W 3 credits 2G S. Matetic

Abstract
This course is composed of various sub-modules related to Cyber Security taught by experts on the relevant fields.

Objective
Students are expected to see behind the curtain of current research and engineering activities related to Cyber Security. At the same time students are introduced to contemporary challenges in cyber security by renowned experts.

Content
The lectures cover contemporary aspects and challenges in Cyber Security. The goal is to present current fields of research/engineering and the latest results. By way of example, Cyber Security Policy is one of sub-modules presented by researchers of the Center for Security Studies at ETH. Besides faculty members of the computer science department, there will be guest lecturers from industry presenting Cyber Security related challenges in their field of activity.

Literature
Will be announced during the course.

DAS in Cyber Security - Key for Type

| W | Eligible for credits | Dr | Suitable for doctorate |
| E- | Recommended, not eligible for credits | O | Compulsory |
| Z | Courses outside the curriculum | W+ | Eligible for credits and recommended |

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium |

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Data in Data Science

### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Students master the basic mathematical concepts and algorithms of estimation and machine learning.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Lecture notes will be handed out as the course progresses.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>solid basics in linear algebra and probability theory</td>
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### Capstone Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>266-0100-00L</td>
<td>Capstone Project</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Supervisors</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The capstone project is part of the DAS in Data Science and is an opportunity to apply the knowledge acquired in the program in an independent, real-world project.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>To apply the knowledge acquired in the program in an independent, real-world project.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The capstone project can be done under the supervision of the Swiss Data Science Center, or of any core or adjunct faculty of Data Science. The project has to be finished within 6 months. Deadline for a project the following semester conducted at the SDSC is mid June/mid December.</td>
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### Specialisation Track

#### Hardware for Machine Learning

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0155-00L</td>
<td>Machine Learning on Microcontrollers</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>M. Magno</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly &quot;smart&quot;: This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the &quot;internet-of-things&quot;, using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V)</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:</td>
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<tr>
<td>- Sensors and sensor data acquisition with low power embedded systems</td>
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<tr>
<td>- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)</td>
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<tr>
<td>- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.</td>
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<tr>
<td>- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Script and exercise sheets. Books will be suggested during the course.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable</td>
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### Image Analysis & Computer Vision

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5902-00L</td>
<td>Computer Vision</td>
<td>W</td>
<td>8 credits</td>
<td>3V+1U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The objectives of this course are:</td>
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</tbody>
</table>

1. To introduce the fundamental problems of computer vision. |
2. To introduce the main concepts and techniques used to solve those. |
3. To enable participants to implement solutions for reasonably complex problems. |
4. To enable participants to make sense of the computer vision literature. |
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on...
### Applied Analysis of Variance and Experimental Design

**401-0625-01L**

**Abstract**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Objective**
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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</tr>
</tbody>
</table>

**401-0649-00L**

**Abstract**
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

**Literature**
- Montgomery et al. (2006): Introduction to Linear Regression Analysis
- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
- Faraway (2006): Extending the Linear Model with R
- Faraway (2005): Linear Models with R

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
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<td></td>
<td></td>
<td>Sensitivity to Diversity</td>
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<td></td>
<td></td>
<td>Negotiation</td>
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</tbody>
</table>

**401-3612-00L**

**Abstract**
This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

**Objective**
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

**Content**

**Lecture notes**
A script will be available in English.
<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Supervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3621-00L</td>
<td>Statistical Modelling</td>
<td>7</td>
<td>G</td>
<td>M. Kalisch</td>
</tr>
<tr>
<td>401-3622-00L</td>
<td>Applied Statistical Regression</td>
<td>9</td>
<td>V+U</td>
<td>J. Ziegel</td>
</tr>
</tbody>
</table>
After this course, you should be able to
- understand the language and concepts of causal inference
- know the assumptions under which one can infer causal relations from observational and/or interventional data
- describe and apply different methods for causal structure learning
- given data and a causal structure, derive causal effects and predictions of interventional experiments

The material covered in this course has a significant overlap with the material that has been covered in 401-3620-22L Student Seminar in Statistics: Causality FS2023.

Parts of this course will be based on the book “Elements of Causal Inference” (MIT Press, open access). More details will follow.

Prerequisites: basic knowledge of probability theory and regression

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Machine Learning and Artificial Intelligence

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0689-00L</td>
<td>System Identification</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>R. Smith</td>
</tr>
<tr>
<td>Abstract</td>
<td>Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.</td>
<td></td>
<td></td>
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<tr>
<td>Objective</td>
<td>To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Control systems (227-0216-00L) or equivalent. Additional papers will be available via the course Moodle.</td>
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| 252-0535-00L | Advanced Machine Learning       | W    | 10 credits | 3V+2U+4A | C. Cotrini Jimenez |
| Abstract     | Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects. |
| Objective    | Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data. |
| Content      | The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data. Topics covered in the lecture include: Fundamentals: What is data? Bayesian Learning Computational learning theory Supervised learning: Ensembles: Bagging and Boosting Max Margin methods Neural networks Unsupervised learning: Dimensionality reduction techniques Clustering Mixture Models Non-parametric density estimation Learning Dynamical Systems |
| Lecture notes | No lecture notes, but slides will be made available on the course webpage. |
| Prerequisites / notice | The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points. |

<table>
<thead>
<tr>
<th>252-3005-00L</th>
<th>Natural Language Processing</th>
<th>W</th>
<th>7 credits</th>
<th>3V+3U+1A</th>
<th>R. Cotterell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7 credits</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
</tr>
<tr>
<td>Literature</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7 credits</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7 credits</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
</tr>
</tbody>
</table>
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and
deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed
exploration of the models and techniques used both in research and in commercial natural language systems.

Objective
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-
oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on
statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed
exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research
and survey papers.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Contact Hours</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>6</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
</tr>
<tr>
<td>263-3210-00L</td>
<td>Deep Learning</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>T. Hofmann</td>
</tr>
</tbody>
</table>
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

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### Prerequisites / notice

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objectives

- How can we build systems that perform well in uncertain environments?
- How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules?
- How can we build systems that learn from experience in order to improve their performance?

We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

#### Topics covered:

- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

---

### Prerequisites / notice

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

---

**Abstract**

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

---

**Guarantees for Machine Learning**

Does not take place this semester.

**Abstract**

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g., in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

Big Data Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

- The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.
- Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-0834-00L | Information Systems for Engineers | W | 4 credits | 2V+1U | G. Fourny

Abstract

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality.
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

- For non-CS/DS students only, BSc and MSc
- Elementary knowledge of set theory and logic
- Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis?

Analytical Competencies

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Communication fostered

Subject-specific Competencies assessed

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start fostered

10 credits

3V+2U+4A

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has fostered

Creative Thinking assessed

Advanced topics in parallel and high-performance computing.

Design of Parallel and High-Performance Computing

W 9 credits

2V+2U+4A

T. Hoefler

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of assessed

Social Competencies Communication fostered

Sensitivity to Diversity fostered

Negotiation fostered

Personal Competencies Creative Thinking fostered

Critical Thinking assessed

263-2800-00L Design of Parallel and High-Performance Computing W 9 credits 2V+2U+4A T. Hoefler

Abstract

Objective

Content

Prerequisites / notice

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3010-00L Big Data W 10 credits 3V+2U+4A G. Fourny

Abstract

Objective

Content

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of assessed

Big Data refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

This course covers a range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 646 of 2667
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Technologies and Technologies
- Storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc.
- Using conventional relational engines as a starting point, the course will aim at providing an in depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Critical Thinking
- The course will place an special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

The participation in the course is subject to the following condition:
- Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Competencies
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Communication fostered
- Personal Competencies: Creative Thinking fostered

Prerequisites / notice
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

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### DAS in Data Science - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
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<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Subjects of Specialization

Subjects are to be chosen from the courses offered in the master degree program in electrical engineering and information technology. The director of studies decides on exceptions, upon consultation with the tutor.

Course offer from the Master Program in Electrical Engineering and Information Technology

Diploma Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

Abstract
This four-hour course covers the basics of writing and presenting scientific work. The focus lies on the structure and the main elements of a scientific text. Formatting guidelines, citation rules, good practice of scientific writing and hints to convince the audience are part of the course.

Objective
- You can write scientific texts using the correct structure
- You can convincingly present scientific work
- You can differentiate the scientific style from novels and news
- You can adhere to citation rules and scientific integrity

Content
The block course covers the following topics:
- Structure of Scientific Texts
- Structure of Scientific Presentations
- Formatting of Scientific Elements (figures, equations, tables)
- Citation Rules and Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
Scientific Integrity, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
You should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Media and Digital Technologies fostered
Social Competencies: Communication fostered
Personal Competencies: Critical Thinking assessed
Self-awareness and Self-reflection fostered

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-3001-00L</td>
<td>Diploma Thesis</td>
<td>O</td>
<td>12 credits</td>
<td>36D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract
The Diploma of Advanced Studies finishes with a 3-months diploma thesis which is directed by a professor of the department ITET. Students prove their ability to conduct independent scientific research on a specific research problem, using skills and knowledge acquired during the program. The thesis includes a written report and an oral presentation.

Objective
see above

DAS in Information Technology and Electrical Engineering - Key for Type

| O | Compulsory |
| W+ | Eligible for credits and recommended |
| W | Eligible for credits |

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |

Key for Hours

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
DAS in Military Sciences

The DAS in Military Sciences programme is executed every second year.

Takes places in Autumn Semester 2023.

Next start: Autumn Semester 2025.

<table>
<thead>
<tr>
<th>DAS in Military Sciences - Key for Type</th>
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<tbody>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
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<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
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Key for Hours

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ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
**DAS in Regenerative Materials**

**Compulsory Module Essentials**

_Wird im Frühjahrssemester angeboten._

**Electives**

**Elective Module Structural Specialisation**

_Wird ab Herbstsemester 2024 angeboten_

**Elective Module Hygrothermal Specialisation**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>136-0201-00L</td>
<td>General Knowledge on Hygrothermal Building Physics</td>
<td>W</td>
<td>2 credits</td>
<td>3G</td>
<td>G. Habert</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>Regenerative Materials can be used to build high-quality envelopes and high-comfort environments. The course presents the basics of hygrothermal building physics and the state of the art in this field. It gives an overview of the type of earth- and bio-based materials that can be used and their hygrothermal properties.</td>
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</tbody>
</table>
| Objective    | - Learn the diversity of regenerative materials used for high-quality envelopes and high-comfort environments  
- Learn how to distinguish earth- and bio-based materials based on their hygrothermal properties  
- Ensure an efficient and durable impact on participants' professional development |      |      |       |           |
| Content      | The course presents which Regenerative Materials can be used to build high-quality envelopes and high-comfort environments. It details the basics of hygrothermal building physics: Evolution of standards and models; Strength and weaknesses of Regenerative Materials; State of the art and market evolution. It also gives an overview of the diversity of earth-based materials (plasters, blocs, monolith walls), bio-based materials with fibers (straw bales, wool and rigid panels, bulk fibers) and low-impact composites (light mixes combining mineral binder to bio-sourced materials) from resource to implementation, with a synthesis of their hygrothermal properties and their impact on comfort and energy savings. |      |      |       |           |
| Competencies | Subject-specific Competencies                  |      |      |       |           |
|              | Concepts and Theories                          |      |      |       |           |
|              | Techniques and Technologies                    |      |      |       |           |
|              | Method-specific Competencies                   |      |      |       |           |
|              | Analytical Competencies                        |      |      |       |           |
|              | Decision-making                                |      |      |       |           |
|              | Social Competencies                            |      |      |       |           |
|              | Self-presentation and Social Influence         |      |      |       |           |
|              | Sensitivity to Diversity                       |      |      |       |           |
|              | Personal Competencies                          |      |      |       |           |
|              | Adaptability and Flexibility                   |      |      |       |           |
|              | Creative Thinking                              |      |      |       |           |
| 136-0202-00L | Constructive Details & Implementation of Regenerative Envelops | W    | 2 credits | 3G   | G. Habert |
|              | Does not take place this semester.             |      |      |       |           |
| Abstract     | The course focused on constructive details for regenerative materials used to build high-quality envelopes and high-comfort environments. The participants are mainly learning through a hands-on workshop during which they will produce different prototypes in small groups. |      |      |       |           |
| Objective    | - Apply knowledge from previous course on high-quality envelopes built with regenerative materials  
- Learn how to compare different constructive systems built with regenerative materials to conventional building techniques considering thermal insulation, thermal mass, moisture regulation and air tightness  
- Ensure an efficient and durable impact on participants' professional development |      |      |       |           |
| Content      | Small groups producing different prototypes during a hands-on workshop. Each group designs and realizes a prototype to explore a specific constructive technique using Regenerative Materials and considering thermal insulation, thermal mass, moisture regulation and air tightness. Monitoring devices will be installed in each prototype. These prototypes are compared to reference prototypes built with conventional building techniques. |      |      |       |           |
| Competencies | Subject-specific Competencies                  |      |      |       |           |
|              | Concepts and Theories                          |      |      |       |           |
|              | Techniques and Technologies                    |      |      |       |           |
|              | Method-specific Competencies                   |      |      |       |           |
|              | Analytical Competencies                        |      |      |       |           |
|              | Decision-making                                |      |      |       |           |
|              | Social Competencies                            |      |      |       |           |
|              | Cooperation and Teamwork                      |      |      |       |           |
|              | Self-presentation and Social Influence         |      |      |       |           |
|              | Sensitivity to Diversity                       |      |      |       |           |
|              | Personal Competencies                          |      |      |       |           |
|              | Adaptability and Flexibility                   |      |      |       |           |
|              | Creative Thinking                              |      |      |       |           |
| 136-0203-00L | Advanced Knowledge on Hygrothermal Assessment | W    | 2 credits | 3G   | G. Habert |
|              | Does not take place this semester.             |      |      |       |           |
| Abstract     | This course offers advanced knowledge on HAM (Heat Air and Moisture) modeling. The most up-to-date simulation models will be presented and used by the participants in real-case projects during simulation workshops. |      |      |       |           |
| Objective    | - Learn how to use the most up-to-date HAM simulation models  
- Learn how to analyse the transient hygrothermal behaviour of an envelope  
- Learn how to run a digital parametric iteration to optimize an envelope  
- Ensure an efficient and durable impact on participants' professional development |      |      |       |           |
| Content      | Advanced knowledge on HAM modeling are presented during simulation workshops:  
- Transient hygrothermal behaviour:  
  - Presentation of relevant software by experts users or developers  
  - Presentation of a case study by the HVAC engineers in charge of the calculation  
  - Calculation exercises based on this case study  
- Digital parametric iteration:  
  - Presentation of relevant software by experts users or developers  
  - Presentation of a case study by the HVAC engineers in charge of the calculation  
  - Calculation exercises based on this case study |      |      |       |           |

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 651 of 2667
### Competencies

#### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

#### Social Competencies
- Self-presentation and Social Influence
- Sensitivity to Diversity

#### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking

#### Analytical Competencies
- Decision-making
- Problem-solving

#### Media and Digital Technologies
- fostered

#### Problem-solving
- fostered

#### Self-presentation and Social Influence
- fostered

#### Sensitivity to Diversity
- fostered

#### Adaptability and Flexibility
- fostered

#### Creative Thinking
- fostered

#### Decision-making
- fostered

#### Problem-solving
- fostered

#### Self-presentation and Social Influence
- fostered

#### Sensitivity to Diversity
- fostered

#### Adaptability and Flexibility
- fostered

#### Creative Thinking
- fostered

### 136-0250-00L Project Work on Hygrothermal Validation

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<th>W</th>
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<td>G. H.</td>
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</table>

#### Abstract
Based on the content of previous courses, the participant are asked to simulate to analyze the hygrothermal behaviour of a building built with the same constructive technique as their prototype. In addition, they have to reproduce the monitoring conditions of their prototypes and compare measurements to simulation results. The result and discussion is presented in front of a jury.

#### Objective
- Apply knowledge from previous courses on a case study
- Learn how to compare measurements to simulation results
- Enhance communication skills concerning high-quality envelopes built with regenerative materials

#### Competencies

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<tr>
<th></th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
</tr>
</thead>
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</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td></td>
</tr>
</tbody>
</table>

#### Social Competencies
- Communication

#### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

#### Diploma Thesis

*Wird im Frühjahrssemester angeboten.*

*Start FS 2024*

### DAS in Regenerative Materials - Key for Type

<table>
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<th>E-</th>
<th>W</th>
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</thead>
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<tr>
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</table>

### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
Gene Technology

**Abstract**
The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.

**Objective**
The course gives an overview of current state-of-the-art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the-art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.

**Content**
I) Genomics and transcriptomics

- **Methods and Techniques:**
  - Recombinant DNA technology
  - Next generation sequencing methods, sequencing of genomes
  - CRISPR technology

- **Application to human biology:**
  - Functional genomics/transcriptomics
  - Principles of cancer, genetic diseases
  - Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

II) Proteomics

- **Methods and Techniques:**
  - Protein cloning and expression
  - The antibody molecule
  - Measurement and determination of biomolecular interactions
  - Protein characterization and engineering
  - Modifications and radioactive labelling

- **Application to human biology:**
  - Protein therapeutics
  - Proteomic approaches for identification of novel disease-related targets and biomarkers

III) Drug discovery: Protein-based libraries

- Immune repertoire mining
- Display and selection technologies
  - 1. antibody phage display
  - 2. other polypeptide display technologies
  - 3. small-molecules display: DNA-encoded chemical libraries

**Lecture notes**
The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Decision-making
  - Problem-solving

- **Personal Competencies**
  - Creative Thinking
  - Critical Thinking
Abstract
The course places the basic pharmaceutical knowledge acquired to date, particularly in pharmacology, in an applied therapeutic context and encourages interdisciplinary thinking in pharmacy. Weekly practical sessions present and discuss common pharmaceutical case studies that may arise in a pharmacist's daily work.

Objective
Students
• are able to independently analyse, present, explain, and discuss simple case studies from pharmacy practice based on their basic knowledge of pharmacy, particularly pharmacology.
• deepen their knowledge of therapeutic classes, drugs, and treatment guidelines.
• are able to analyse the pharmacological profiles of selected drugs in a therapeutic context (e.g., with regard to adverse drug reactions and interactions).
• are able to compare different drugs and derive therapy-relevant characteristics.

Content
Pharmaceutical case studies from different therapeutic fields comprehend following subject areas:
• Indication
• Dosage Form
• Adverse Drug Reactions
• Interactions
• Contraindications

Lecture notes
Is made available via Moodle.

Literature
As stated in the cases.

Prerequisites / notice
The lecture Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

The course takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and discussed in plenary.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

535-0521-00L Pharmacology and Toxicology I O 3 credits 2V U. Quitterer, J. Abdo Alla

Abstract
This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

Objective
The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

Content
Topics include disease-relevant macroscopic, microscopic, pathobiological and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicology, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.
A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

Recommended reading:


The classic textbook in Pharmacology:


Prerequisites / notice

Voraussetzungen: Abschluss Grundstudium

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
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Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
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Second Series of Courses (Group A)

Compulsory Courses I

<table>
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<tr>
<td>535-5512-00L</td>
<td>Triage, Diagnostics, Therapy Support</td>
<td>0</td>
<td>9</td>
<td>12G</td>
<td>E. Kut Bacs, F. Bortoli, A. Burch, S. Erni, P. Obrist, S. Ruppen, E. Trauffer, I. S. Vogel Kahmann</td>
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</table>

Abstract

This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases.

Objective

Students

- know and understand the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, classes of active ingredients and selected, practice-relevant drugs (including indications and the most frequent and important adverse drug reactions, interactions and contraindications).

Content

"Pharmaceutical Care" und "Health Care";
Häufigste Erkrankungen und Therapien der
- Allergologie
- Angiologie und Hämatologie
- Dermatologie
- Endokrinologie und Diabetologie
- Gastroenterologie
- Infektiologie
- Kardiologie
- Neurologie
- Ophthalmologie
- Otorhinolaryngologie
- Pneumologie
- Psychiatrie
- Rheumatologie
- Urologie

Lecture notes

Provided via moodle.

Literature

As stated in the lecture notes.
The course consists of two parts: Pharmacology and Toxicology III must be visited at the same time.

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<thead>
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### Compulsory Courses II

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<td>Pharmaceutical Immunology II &amp; Therapeutic Proteins</td>
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<td>3</td>
<td>3G</td>
<td>C. Halin Winter, D. Neri</td>
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- **Prerequisites / notice**: Students know and understand:
  - basic mechanisms and regulation of the immune response
  - the pathogenic mechanisms of the most important immune-mediated disorders
  - the concepts of vaccination and cancer immunotherapy
  - the most frequently used expression systems for the production of therapeutic proteins
  - the use of protein engineering tools for modifying different features of therapeutic proteins
  - the mechanism of action of selected therapeutic proteins and their application
  - basic concepts in the GMP production of therapeutic proteins

- **Abstract**: In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

- **Objective**: The course consists of two parts:
  - In the first part, students will complete their training in Pharmaceutical Immunology. This part particularly focuses on the pathogenic mechanisms of immune-mediated diseases, vaccination and cancer immunotherapy. Deepened knowledge of immunology will be relevant for understanding the mechanism of action of many therapeutic proteins, as well as for understanding one major concern related to the use of protein-based drugs, namely, immunogenicity.
  - The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

- **Content**: Handouts to the lectures will be available for downloading under [http://www.pharma.ethz.ch/scripts/index](http://www.pharma.ethz.ch/scripts/index).

### Literature

- Janeway's Immunobiology, by Kenneth Murphy (9th or 10th Edition)
- Lecture Handouts
- Paper References provided in the Scripts
- EMEA Dossier for Humira

### Prerequisites / notice

- **Prerequisites**: Either 535-0830-00L Pharmaceutical Immunology I or 551-0317-00L Immunology I

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**Abstract**: The course is divided into three parts. The first part provides an overview of drugs used for the pharmacotherapy of infectious diseases, osteoporosis, autoimmune diseases and cancer. The second part gives an overview of the field of medical virology, and the third part is focused on pharmacogenomics of drug metabolism and basic concepts of toxicology.

**Objective**: The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases, osteoporosis, autoimmune diseases and cancer. The course also provides an overview of the fields of medical virology, toxicology, and pharmacogenomics with a special focus on the role of genetic polymorphisms in drug response and adverse effects.

**Content**: Topics include the pharmacology and pharmacotherapy of infectious diseases, osteoporosis, autoimmune diseases and cancer. Medical virology covers important viral infections and their pharmacotherapy with different classes of antiviral drugs. In the field of pharmacogenomics, the course is focused on examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development. Finally, basic concepts of toxicology are introduced.

**Lecture notes**: A script is provided for each lecture. The scripts define important and exam-relevant contents of the lectures. Scripts do not replace the lectures.
### Literature

#### Recommended reading:
- The classic textbook in Pharmacology: *Goodman and Gilman’s The Pharmacological Basis of Therapeutics* by Laurence Brunton, Bjorn C. Knollman. 14th edition (2022)
  - ISBN-10: 1264258070
  
- or

#### Competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

### Second Series of Courses (Group B)

#### 535-0050-00L Pharmacoepidemiology and Drug Safety

**Abstract**
Introduction to the principles, methods and applications of pharmacoepidemiology and drug safety. Drug safety in the pharmaceutical industry and regulatory authorities, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.

**Objective**
- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for clinical pharmacists in hospitals and office pharmacies.
- Perform independently a causality assessment of suspected adverse drug reactions in patients
- Study designs and biostatistics used for the quantitative evaluation of drug safety
- Setup of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals

**Content**
- Historical landmarks of drug safety
- Pharmacovigilance and causality assessment
- Drug safety in premarketing clinical trials
- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding
- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPs)
- Medication errors, clinical pharmacy / clinical pharmacology
- Clinical Decision Support Systems, Interventional Pharmacoepidemiology
- Pharmacoepidemiological databases, ‘Big Data’
- Interactive discussion of many real-life examples for each topic

**Lecture notes**
This course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through seminars, case studies in small groups. Reading material and scripts will be provided for each week.

**Literature**
- Rothman: Introduction to Epidemiology
- Strom, Kimmel, Hennessy: Textbook of Pharmacoepidemiology
- Gigerenzer: Risk Savvy - How to Make Good Decisions

#### 535-0137-00L Clinical Chemistry II

**Abstract**
Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Objective**
- Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interpete selected tests.
- Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Lecture notes**
Documentation will be available before the lectures electronically.

**Literature**
- Jürgen Hallbach, *Klinische Chemie und Hämatologie für den Einstieg*, Thieme Verlag
- Harald Renz, *Praktische Labordiagnostik*, de Gruyter Verlag
- Walter Guder, *Das Laborbuch für Klinik und Praxis*, Elsevier Verlag
- Lothar Thomas, *Labor und Diagnose*, TH Books

**Prerequisites / notice**
- Requirement: basic knowledge in clinical chemistry and laboratory diagnostics

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**Data:** 02.07.2024 12:39  |  **Autumn Semester 2024**  |  **Page 657 of 2667**
Abstract

This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases.

Objective

Students

- know and understand the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, classes of active ingredients and selected, practice-relevant drugs (including indications and the most frequent and important adverse drug reactions, interactions and contraindications).

Content

"Pharmaceutical Care" und "Health Care":
Häufigste Erkrankungen und Therapien der
- Allergologie
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- Infektiologie
- Kardiologie
- Neurologie
- Ophthalmologie
- Otorhinolaryngologie
- Pneumologie
- Psychiatrie
- Rheumatologie
- Urologie

Lecture notes

Provided via moodle.

Literature

As stated in the lecture notes.

Prerequisites / notice

Please note that the assessment of this course must be passed (not compensable).

The performance assessment of the course takes place in two written on campus online partial examinations. The overall grade results from the average of the grades of both partial examinations. If the overall grade is unsatisfactory, both partial examinations must be repeated.

The courses Pharmacology and Toxicology I and II and Pathobiology provide indispensable basics which students must master at the beginning of the semester in order to successfully complete the course.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies

Communication fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered

Personal Competencies

Adaptability and Flexibility fostered
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Objective

Students know and understand the therapeutic concepts of the mentioned topics and their application in practice.

(for detailed learning objectives see the guidelines)

Content

- complementary medicine
- phytotherapy
- wound care
- pharmaceutical care
- nephrology

Lecture notes

Provided via myStudies.

Literature

As specified in the lecture notes

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535-5522-00L Therapeutic Skills II

Abstract

This course provides basic clinical and pharmaceutical knowledge and its application for triage, diagnostics and therapy support for the most common diseases in geriatrics, women's health, oncology, paediatrics and neurology (epilepsy). In addition, the role of nutrition in special life situations and in selected health disorders is taught.

Objective

- know and understand the pathomechanisms and the clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed.
- can triage patients by applying this knowledge: i.e. analyse simple symptoms and disease patterns, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, drug classes and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

(for detailed learning objectives, see the guideline)

Content

- nutrition
- geriatrics
- neurology (epilepsy)
- oncology
- paediatrics
- women's health

Lecture notes

Provided via myStudies.

Literature

As specified in the lecture notes

Competencies

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535-5524-00L Clinical Trainings

Abstract

Basic training on and around patients with practical confrontation. The path of acute patients from patient presentation, through triage and diagnostics to therapy.

Objective

Students will be able to understand the medical-clinical way of thinking for the diagnosis and treatment of acute patients. They complete the change of perspective from the molecular mechanism of action of drugs to the treatment of patients in all its complexity. Using real patient examples, students acquire exemplary knowledge in diagnostics and triage as well as therapy selection and therapy support. They consolidate their understanding of the importance of pharmaceutical care before and after hospitalization.

Content


535-5502-00L Pharmaceutical Manufacturing in Small Quantities (Compounding)

Abstract

Basic training on and around patients with practical confrontation. The path of acute patients from patient presentation, through triage and diagnostics to therapy.

Objective

Students will be able to understand the medical-clinical way of thinking for the diagnosis and treatment of acute patients. They complete the change of perspective from the molecular mechanism of action of drugs to the treatment of patients in all its complexity. Using real patient examples, students acquire exemplary knowledge in diagnostics and triage as well as therapy selection and therapy support. They consolidate their understanding of the importance of pharmaceutical care before and after hospitalization.

Content


Data: 02.07.2024 12:39
Autumn Semester 2024
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Abstract
Pharmaceutical Manufacturing relevant for the community pharmacy considering the “GMP-Regeln in kleinen Mengen” of the 
Pharmakopoea: The preparation of extemporaneous products covering the most common forms under consideration of their 
and Quality Assurance.

Objective
The students are able to produce pharmaceutical relevant drug Systems without further assistance, lege arts, applying the right techniques 
and material. The production and packaging has to follow GMP rules and tailored for the patients need. The quality control and correct 
documentation have to be followed. The students know the most relevant specifications, concentration and dosing ranges of common APIs 
and excipients. The students are familiar with the relevant literature (Pharmaceutical and legal basis) regarding the Pharmaceutical 
manufacturing relevant for the community pharmacies

Content
Vermittlung der wichtigsten Kenntnisse, Arbeitsschritte und -techniken im Bereich der Arzneimittelherstellung in kleinen Mengen (Formula) 
mit Fokus auf der Herstellung, Qualitätssicherung und Risikobeurteilung einschliesslich der patientenspezifischen Abgabepraparate.

Prerequisites / notice
Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Competencies

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535-5503-00L Institutional Pharmacy ■ Does not take place this semester.

Abstract
Organisation of institutional environments (emergency hospitals), with special focus on the medication process and institutional 
pharmaceutical care (continuum of care).

Objective
Students understand the concept of continuum of care and its practical implementation. They know the medication process within an 
institutional environment. They are able to find the necessary information and deal with problems in connection with pharmaceuticals, to 
evaluate them and to communicate and documentate their findings adequately. They know how a hospital is organised (procedures, 
possible problems), responsibilities of the different members of the staff and, most importantly, what the function of a hospital pharmacy is. 
Principals of the organisation of institutional environments (emergency hospitals), with special focus on medication processes and 
institutional pharmaceutical care (circulation of medication, continuum of care). Hygiene regulations, medical products, applications, drug 
formularies, patient files, SOAP notes, kardex study. Participation at interdisciplinary visits, internal trainings and doctors' reports as well as 
vistation of the emergency room. Drug interaction, generic substitution, quality management and pharmacovigilance.

Content

535-5526-00L Injection Techniques and Vaccinations ■ O 2 credits 3G I. S. Vogel Kahmann, C. Hallin Winter

Abstract
Die Studierenden erlernen die praktische Durchführung von subkutanen (s.c.) und intramuskulären (i.m.) Injektionen. Sie wissen, wie in 
Notfallsituationen vorzugehen ist.

Objective
Die Studierenden kennen die in der Schweiz zur Verfügung stehenden Impfunterlagen, den schweizerischen Impfplan und sind vertraut mit der 
zu handeln.

Content
Die Studierenden kennen die rechtlichen Grundlagen und regulatorischen Aspekte bezüglich der Arzneimittelherstellung in der Apotheke. 
Die Studierenden kennen verschiedene Verbandmaterialien und können diese anwenden, um akute Wunden zu versorgen.

Lecture notes
Die Lernziele und Inhalte entsprechen dem Fähigkeitsprogramm FPPh Impfen und Blutentnahme von PharmaSuisse (ausser venöse 
Blutentnahmen)

Prequisites / notice
Die Injektionsübungen werden an Mitsstudierenden durchgeführt.

Literature
Wird in Skript angegeben.

Schutzkonzept: https://chab.ethz.ch/studium/bachelor1.html
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**DAS Preparation for the Swiss Federal Examination in Pharmacy - Key for Type**

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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td>Z</td>
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**Key for Hours**

<table>
<thead>
<tr>
<th>Code</th>
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<tbody>
<tr>
<td>V</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
## Core Courses

### Data Analysis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

**Abstract**

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

**Content**

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

**Lecture notes**

No lecture notes, but slides will be made available on the course webpage.

**Literature**


### Prerequisites / notice

- The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.
- Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.
- PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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### Probabilistic Artificial Intelligence

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>263-5210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>A. Krause</td>
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</tbody>
</table>

**Abstract**

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

**Content**

Topics covered:

- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

**Prerequisites / notice**

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 662 of 2667
Mathematics of Data Science

Abstract
Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

Objective
Introduction to various mathematical aspects of Data Science.

Content
These topics lie in overlaps of Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Most lectures will feature Mathematical Open Problems. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

Lecture notes

Prerequisites / notice
The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Sensitivity to Diversity fostered

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Data Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>263-3010-00L</td>
<td>Big Data</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>G. Fourny</td>
</tr>
</tbody>
</table>

Abstract
The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data Universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking

263-3845-00L

Data Management Systems

W 8 credits 3V+1U+3A G. Alonso

Abstract
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Objective
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Literature
The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.
Prerequisites / notice
The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

263-4500-00L Advanced Algorithms
W 9 credits 3V+2U+3A J. Lengler, B. Häupler, M. Probst

Abstract
This is a graduate-level course on algorithm design (and analysis). It covers a range of topics and techniques in approximation algorithms, sketching and streaming algorithms, and online algorithms.

Objective
This course familiarizes the students with some of the main tools and techniques in modern subareas of algorithm design.

Content
The lectures will cover modern topics in algorithm design and analysis, including the following: graph sparsifications while preserving cuts or distances, various approximation algorithms techniques and concepts, metric embeddings and probabilistic tree embeddings, online algorithms, multiplicative weight updates, streaming algorithms, sketching algorithms.

Lecture notes
https://people.inf.ethz.ch/~aroeyskoe/A23

Prerequisites / notice
This course is designed for masters and doctoral students and it especially targets those interested in theoretical computer science, but it should also be accessible to last-year bachelor students.

Sufficient comfort with both (A) Algorithm Design & Analysis and (B) Probability & Concentrations. E.g., having passed the course Algorithms, Probability, and Computing (APC) is recommended, though not required formally. If you are not sure whether you're ready for this class or not, please consult the instructor.

Competencies
Subject-specific Competencies
Concepts and Theories
Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Autumn Semester 2024

Electives

Subject-Specific Electives

Number Title Type ECTS Hours Lecturers
261-5130-00L Research in Data Science W 6 credits 13A Professors

Abstract
Independent work under the supervision of a core or adjunct faculty of data science.

Objective
Independent work under the supervision of a core or adjunct faculty of data science.

Content
Project done under supervision of an approved professor.

Prerequisites / notice
Only students who have passed at least one core course in Data Management and Processing, and one core course in Data Analysis can start with a research project.

A project description must be submitted at the start of the project to the studies administration.

252-3005-00L Natural Language Processing W 7 credits 3V+3U+1A R. Cotterell

Abstract
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

263-2400-00L Reliable and Trustworthy Artificial Intelligence W 6 credits 2V+2U+1A M. Vechev

Abstract
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Objective
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.
The course is split into 4 parts:

**Robustness of Machine Learning**

- Adversarial attacks and defenses on deep learning models.
- Certified training of deep neural networks (combining symbolic and continuous methods).

**Privacy of Machine Learning**

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across vision, natural language and tabular data).
- Differential privacy for defending machine learning.
- AI Regulations and checking model compliance.

**Fairness of Machine Learning**

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness (for both vision and tabular data).
- Enforcing group fairness (e.g., demographic parity, equalized odds).

**Robustness, Privacy and Fairness of Foundation Models**

- We discuss all previous topics, as well as programmability, in the context of latest foundation models (e.g., LLMs).


**Prerequisites / notice**

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<tr>
<td></td>
<td>Problem-solving</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</table>

**263-3210-00L Deep Learning**

*Abstract*

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

*Objective*

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/aml/

  Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/

  Introduction to Machine Learning
  https://las.inf.ethz.ch/teaching/introml-S19

  Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/slt/

  Computational Statistics
  https://stat.ethz.ch/lectures/ss19/comp-stats.php

  Probabilistic Artificial Intelligence
  https://las.inf.ethz.ch/teaching/pai-f18

**263-5005-00L Artificial Intelligence in Education**

*Abstract*

Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.

*Objective*

The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student-facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture notes
No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

Prerequisites / notice
There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

263-5056-00L
Applications of Deep Learning on Graphs
Does not take place this semester.

Abstract
Graphs are an incredibly versatile abstraction to represent arbitrary structures such as molecules, relational knowledge or social and traffic networks. This course provides a practical overview of deep (representation) learning on graphs and their applications.

Objective
Many established deep learning methods require dense input data with a well-defined structure (e.g. an image, a sequence of word embeddings). However, many practical applications deal with sparsely connected and complex data structures, such as molecules, knowledge graphs or social networks. Graph Neural Networks (GNNs) and general representation learning on graphs have recently experienced a surge in popularity because it addresses the challenge to effectively learn representations over said structures. In this course, we aim to understand the fundamental principles of deep (representation) learning on graphs, the similarities and differences to other concepts in deep learning, as well as the unique challenges from a practical point of view. Finally, we provide an overview of recent applications of graph neural networks.

Content
Introduction to GNN concepts: 1) problem-solving on graphs (node-, edge-, graph-level objectives), structural priors (inductive biases) of graph data applications for graph learning. 2) Graph Neural Networks: convolutional, attentional, message passing; overview on the zoo of published operators. Relations to Transformers and DeepSets. 3) Expressivity of GNNs. 4) Scalability of Graph Neural Networks: Subsampling, Clustering (Pooling). 5) Augmentations and self-supervised learning on Graphs Application: Drug Discovery, Knowledge graphs, Temporal GNNs, Geometric GNNs, Deep Generative Models for Graphs.

Prerequisites / notice
263-3210-00 Dep Deep learning or 263-0008-00 Computational Intelligence Lab; 252-0220-00 Introduction to Machine Learning; Statistics/Probability; Programming in Python; Unix Command Line.

263-5300-00L
Guarantees for Machine Learning
Does not take place this semester.

Abstract
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective
By the end of the semester students should be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression", "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity— including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Compeirencies
Subjects-specific Competencies: Concepts and Theories, Analytical Competencies assessed
System-specific Competencies: Method-specific Competencies assessed, Problem-solving assessed
Social Competencies: Communication assessed, Cooperation and Teamwork assessed
Personal Competencies: Creative Thinking assessed, Critical Thinking assessed

263-5351-00L
Machine Learning for Genomics

Abstract
The course reviews solutions provided by machine learning to the most challenging questions in human genomics.
Over the last few years, the parallel development of machine learning methods and molecular profiling technologies for human cells, such as sequencing, created an extremely powerful tool to get insights into the cellular mechanisms in healthy and diseased contexts. In this course, we will discuss the state-of-the-art machine learning methodology solving or attempting to solve common problems in human genomics. At the end of the course, you will be familiar with (1) classical and advanced machine learning architectures used in genomics, (2) bioinformatics analysis of human genomic and transcriptomic data, and (3) data types used in this field.

- Short introduction to major concepts of molecular biology: DNA, genes, genome, central dogma, transcription factors, epigenetic code, DNA methylation, signaling pathways
- Prediction of transcription factor binding sites, open chromatin, histone marks, promoters, nucleosome positioning (convolutional neural networks, position weight matrices)
- Prediction of variant effects and gene expression (hidden Markov models, topic models)
- Deconvolution of mixed signal (NMF, ICA)
- DNA, RNA and protein folding (RNN, LSTM, transformers)
- Data imputation for single-cell RNA-seq data, clustering and annotation (diffusion and methods on graphs)
- Batch correction (autoencoders, optimal transport)
- Survival analysis (Cox proportional hazard model, regularization penalties, multi-omics, multi-tasking)

Introduction to Machine Learning, Statistics/Probability, Programming in Python, Unix Command Line

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayses Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Script and exercise sheets. Books will be suggested during the course.

Prerequisites / notice

Introduction to Machine Learning, Statistics/Probability, Programming in Python, Unix Command Line

Machine Learning on Microcontrollers

Registration in this class requires the permission of the instructors. Preference is given to students in the MSc EEIT.

Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly “smart”. This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the “internet-of-things”, using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V)

Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ECG bio-sensors, cameras...). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

The final goal of the course is to couple with deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Script and exercise sheets. Books will be suggested during the course.

Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

The fundamentals of Information Theory including Shannon’s source coding and channel coding theorems

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Elements of Information Theory (second edition)

Machine learning and Artificial Intelligence for Autonomous Cars

Up until FS2022 offered as Deep Learning for Autonomous Driving

This course introduces the core computer vision techniques and algorithms that autonomous cars use to perceive the semantics and geometry of their driving environment, localize themselves in it, and predict its dynamic evolution. Emphasis is placed on techniques tailored for real-world settings, such as multi-modal fusion, domain-adaptive and outlier-aware architectures, and multi-agent methods.
Objective

Students will learn about the fundamentals of autonomous cars and of the computer vision models and methods these cars use to analyze their environment and navigate themselves in it. Students will be presented with state-of-the-art representations and algorithms for semantic, geometric and temporal visual reasoning in automated driving and will gain hands-on experience in developing computer vision algorithms and architectures for solving such tasks.

After completing this course, students will be able to:
1. understand the operating principles of visual sensors in autonomous cars
2. differentiate between the core architectural paradigms and components of modern visual perception models and describe their logic and the role of their parameters
3. systematically categorize the main visual tasks related to automated driving and understand the primary representations and algorithms which are used for solving them
4. critically analyze and evaluate current research in the area of computer vision for autonomous cars
5. practically reproduce state-of-the-art computer vision methods in automated driving
6. independently develop new models for visual perception

Content

The content of the lectures consists in the following topics:

1. Fundamentals
   (a) Fundamentals of autonomous cars and their visual sensors
   (b) Fundamental computer vision architectures and algorithms for autonomous cars

2. Semantic perception
   (a) Semantic segmentation
   (b) Object detection
   (c) Instance segmentation and panoptic segmentation

3. Geometric perception and localization
   (a) Depth estimation
   (b) 3D reconstruction
   (c) Visual localization
   (d) Unimodal visual/lidar 3D object detection

4. Robust perception: multi-modal, multi-domain and multi-agent methods
   (a) Multi-modal 2D and 3D object detection
   (b) Visual grounding and verbo-visual fusion
   (c) Domain-adaptive and outlier-aware semantic perception
   (d) Vehicle-to-vehicle communication for perception

5. Temporal perception
   (a) Multiple object tracking
   (b) Motion prediction

The practical projects involve implementing complex computer vision architectures and algorithms and applying them to real-world, multi-modal driving datasets. In particular, students will develop models and algorithms for:

1. Semantic segmentation and depth estimation
2. Sensor calibration for multi-modal 3D driving datasets
3. 3D object detection using lidars

Lecture notes

Lecture slides are provided in PDF format.

Prerequisites / notice

Students are expected to have a solid basic knowledge of linear algebra, multivariate calculus, and probability theory, and a basic background in computer vision and machine learning. All practical projects will require solid background in programming and will be based on Python and libraries of it such as PyTorch.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

Abstract

Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.

Objective

To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content

Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Closed-loop identification strategies. Trade-off between controller performance and information available for identification.


Prerequisites / notice

Students are expected to have a solid basic knowledge of linear algebra, multivariate calculus, and probability theory, and a basic background in computer vision and machine learning. All practical projects will require solid background in programming and will be based on Python and libraries of it such as PyTorch.

Literature

Additional papers will be available via the course Moodle.

401-0625-01L

Applied Analysis of Variance and Experimental Design

W 5 credits 2V+1U  L. Meier
Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorial designs and fractional power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorial designs and fractional power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies: Analytical Competencies assessed
Decision-making assessed

Personal Competencies: Critical Thinking assessed

401-3054-14L Probabilistic Methods in Combinatorics
W 5 credits 2V+1U B. Sudakov

Abstract
This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content
The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

Literature
- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

401-3055-64L Algebraic Methods in Combinatorics
W 5 credits 2V+1U not available

Abstract
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments. Spaces of polynomials and tensor product methods. Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

401-3601-00L Probability Theory
W 9 credits 4V+1U V. Tassion

Abstract
At most one of the three course units (Bachelor Core Courses)
401-3641-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

Objective
Basics of probability theory and the theory of stochastic processes in discrete time

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
measure theory, formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé–Galton–Watson process and its R-number, convergence in distribution and the central limit theorem.

### Lecture notes

Will be available in electronic form.

### Literature


### Prerequisites

**Objective**

To gain insight into the main statistical ideas and concepts.

- Basic notions in probability theory (probability space, conditional probability, Borel Cantelli, Dynkin Lemma, random variables, expectation, variance, law of large numbers).

- Measure Theory

### Competencies

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Personal Competencies**

- Creative Thinking

### 401-3612-00L Stochastic Simulation (W 5 credits)

**Abstract**

This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

**Objective**

Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

**Content**

- Examples of simulations in different fields (computer science, statistics, statistical mechanics, operations research, financial mathematics).
- Generation of uniform random variables.
- Generation of random variables with arbitrary distributions (quantile transform, accept-reject, importance sampling), simulation of Gaussian processes and diffusions. The precision of simulations, methods for variance reduction, introduction to Markov chains and Markov chain Monte Carlo (Metropolis-Hastings, Gibbs sampler, Hamiltonian Monte Carlo, reversible jump MCMC).
- Stochastic Simulation

### Lecture notes

A script will be available in English.

### Literature


**Prerequisites**

- Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

### 401-3622-00L Statistical Modelling (W 7 credits)

**Abstract**

In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

**Objective**

Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

**Content**

- In the regression will be subject to the consideration of the simulation of quantitatively given quantities from one or more other variables (under Berücksichtigung zufälliger Fehler) untersucht. Themen der Vorlesung sind: Einfache und multiple Regression, Theorie allgemeiner linearer Modelle, Hoch-dimensionale Modelle, Ausblick auf nichtlineare Modelle, Querverbindungen zur Varianzanalyse, Modellsuche, Residuenanalyse, Einblicke in Robuste Regression. Durchrechnung und Diskussion von Anwendungsbeispielen.

**Prerequisites**

- This is the course unit with former course title "Regression".

- Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

### 401-3621-00L Fundamentals of Mathematical Statistics (W 9 credits)

**Abstract**

In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

**Objective**

The aim of this course is to gain insight into the main statistical ideas and concepts.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Problem-solving

- Method-specific Competencies
  - Analytical Competencies
  - Problem-solving

- Personal Competencies
  - Creative Thinking

### 401-4623-00L Time Series Analysis (W 4 credits)

**Abstract**

The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

**Objective**

The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:

- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting

Abstract
In statistics, we are used to search for the best predictors of some random variable. In many situations, however, we are interested in predicting a system's behavior under manipulations. For such an analysis, we require knowledge about the underlying causal structure of the system. In this course, we study concepts and theory behind causal inference.

Objective
After this course, you should be able to
- understand the language and concepts of causal inference
- know the assumptions under which one can infer causal relations from observational and/or interventional data
- describe and apply different methods for causal structure learning
- given data and a causal structure, derive causal effects and predictions of interventional experiments

Content
The material covered in this course has a significant overlap with the material that has been covered in 401-3620-22L Student Seminar in Statistics: Causality FS2023.

Literature
Parts of this course will be based on the book "Elements of Causal Inference" (MIT Press, open access). More details will follow.

Competencies
- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Prerequisites / notice
Prerequisites: basic knowledge of probability theory and regression

151-0563-01L Dynamic Programming and Optimal Control

Abstract
Introduction to Dynamic Programming and Optimal Control.

Objective
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Interdisciplinary Electives

No. Title Type ECTS Hours Lecturers
261-5112-00L Algorithms and Data Structures for Population Scale Genomics W 3 credits 2G A. Kahles

Abstract
Research in Biology and Medicine have been transformed into disciplines of applied data science over the past years. Not only size and inherent complexity of the data but also requirements on data privacy and complexity of search and access pose a wealth of new research questions.

Objective
This interactive course will explore the latest research on algorithms and data structures for population scale genomics applications and give insights into both the technical basis as well as the domain questions motivating it.

Competencies
- Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Media and Digital Technologies
- Cooperation and Teamwork
- Critical Thinking
- Integrity and Work Ethics

Machine Learning for Genomics

Abstract
The course reviews solutions provided by machine learning to the most challenging questions in human genomics.

Objective
Over the last few years, the parallel development of machine learning methods and molecular profiling technologies for human cells, such as sequencing, created extremely powerful tools to get insights into the cellular mechanisms in healthy and diseased contexts. In this course, we will discuss the state-of-the-art machine learning methodology solving or attempting to solve common problems in human genomics. At the end of the course, you will be familiar with (1) classical and advanced machine learning architectures used in genomics, (2) bioinformatics analysis of human genomic and transcriptomic data, and (3) data types used in this field.
<table>
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<th>Course Code</th>
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<td>636-0017-00L</td>
<td>Computational Biology</td>
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<td>Abstract</td>
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<td>The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.</td>
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<td>Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:</td>
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<td>* stochastic models in molecular evolution</td>
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<td>* phylogenetics &amp; phylodynamic inference</td>
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<td>* maximum likelihood and Bayesian statistics</td>
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<td>Attendees will apply these concepts to a number of applications yielding biological insight into:</td>
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<td>* epidemiology</td>
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<td>* pathogen evolution</td>
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<td>* macroevolution of species</td>
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<td>The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylogeography, the aim of which is to understand and quantify population dynamics (such as transmission in epidemiology or speciation &amp; extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.</td>
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<td>Lecture notes</td>
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<td>Lecture slides will be available on moodle.</td>
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<td>The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:</td>
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<td>* Yang, Z. 2006. Computational Molecular Evolution.</td>
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<td>* Drummond, A. &amp; Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.</td>
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<td>Prerequisites / notice</td>
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<td>(compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.</td>
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<td>Decision-making</td>
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<td>Creative Thinking</td>
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<td>252-1411-00L</td>
<td>Security of Wireless Networks</td>
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<td>Abstract</td>
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<td>This course discusses physical layer aspects of wireless communication and a wide range of security-related topics in the domain of wireless technologies. It mainly targets computer science students. Though useful, a background in signal processing or physical layer concepts is not required. A basic understanding of security (e.g. as taught in 252-0211.00L Information Security) is recommended.</td>
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<td>After this course, students should be able to describe and classify security goals of and attacks on various wireless networks and technologies, with an emphasis on physical layer aspects.</td>
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<td>- Introduction to wireless communication</td>
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<td>- Physical layer security schemes</td>
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<td>- Spreading techniques and their application in jamming-resilient communication and Global Navigation Satellite Systems (GNSSs)</td>
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<td>- Secure ranging with Ultra-Wide Band (UWB)</td>
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<td>- Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)</td>
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<td>Competencies</td>
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<tr>
<td>227-0575-00L</td>
<td>Advanced Topics in Communication Networks</td>
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<td></td>
<td>Abstract</td>
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<td>This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall. Repetition for credit is possible with the consent of the instructor.</td>
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<td>The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom Deutsche Telecom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be “hands-on” and will enable students to play with the technologies in realistic network environments.</td>
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In 2023, the course will cover advanced topics in communication networks such as:
- Advanced Internet routing (convergence, optimality, scalability, flexibility);
- Network programmability (OpenFlow, P4);
- Traffic engineering / Load Balancing;
- Network verification and synthesis;
- Network measurements;
- Network security;
- Upcoming transport protocols and technologies;
- Adaptive video streaming; and
- Network sustainability.

The course will be composed of lectures and practical exercises (some of which including labs).

Lecture notes
Lecture notes and material will be made available before each course on the course website.

Literature
Relevant references will be made available through the course website.

Prerequisites / notice
Prerequisites: Communication Networks (227-0120-00L) or equivalents / programming skills (in any language) are expected (some of the exercises will involve coding).

Competencies
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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<tr>
<th>263-4640-00L</th>
<th>Network Security</th>
<th>8 credits</th>
<th>2V+2U+3A</th>
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<tr>
<td>W</td>
<td>P. de Vaere, S. Frei, K. Paterson, A. Perrig</td>
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</table>

Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Competencies
| Subject-specific Competencies          | Concepts and Theories | assessed |
|                                        | Techniques and Technologies | assessed |
| Method-specific Competencies           | Analytical Competencies | assessed |
|                                        | Decision-making       | assessed |
|                                        | Media and Digital Technologies | assessed |
|                                        | Problem-solving       | assessed |
|                                        | Project Management    | assessed |
| Social Competencies                    | Communication         | fostered |
|                                        | Cooperation and Teamwork | fostered |
|                                        | Customer Orientation  | fostered |
|                                        | Leadership and Responsibility | fostered |
|                                        | Self-presentation and Social Influence | fostered |
|                                        | Sensitivity to Diversity | fostered |
|                                        | Negotiation           | fostered |
| Personal Competencies                  | Adaptability and Flexibility | fostered |
|                                        | Creative Thinking      | assessed |
|                                        | Critical Thinking      | assessed |
|                                        | Integrity and Work Ethics | fostered |
|                                        | Self-awareness and Self-reflection | fostered |
|                                        | Self-direction and Self-management | assessed |

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<tr>
<th>401-3913-01L</th>
<th>Mathematical Foundations for Finance</th>
<th>4 credits</th>
<th>3V+2U</th>
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<td>W</td>
<td>D. Possamaï</td>
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Abstract
First introduction to main modelling ideas and mathematical tools from mathematical finance.

Objective
This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.
Topics to be covered include:

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

Lecture notes:
See information on course homepage

Prerequisites / notice:
Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitslehre").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

Competencies:

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

401-3922-00L  Life Insurance Mathematics

Abstract
The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

401-3925-00L  Non-Life Insurance: Mathematics and Statistics

Abstract
The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.

Objective
The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.

Content
The following topics are treated:
- Collective Risk Modeling
- Claim Counts Models
- Individual Claim Size Modeling
- Censoring and Truncation
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tariffication
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

Lecture notes
M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics
http://ssrn.com/abstract=2319328

Literature
M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications

Prerequisites / notice
This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

Competencies:

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

401-3922-00L  Life Insurance Mathematics

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The following topics are treated:
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Prerequisites / notice
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Competencies:

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

621-5111-00L  Asset Management: Advanced Investments
(University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: MFOEC207

Mind the enrolment deadlines at UZH:

Abstract
Comprehension and application of advanced portfolio theory

Objective
Comprehension and application of advanced portfolio theory
The theoretical part of the lecture consists of the topics listed below.

- Standard Markowitz Model and Extensions
- MV Optimization, MV with Liabilities and CAPM.
- The Crux with MV
- Resampling, regression, Black-Litterman, Bayesian, shrinkage, constrained and robust optimization.
- Downside and Coherent Risk Measures
- Definition of risk measures, MV optimization under VaR and ES constraints.
- Risk Budgeting
- Equal risk contribution, most diversified portfolio and other concentration indices
- Regime Switching and Asset Allocation
- An introduction to regime switching models and its intuition.
- Strategic Asset Allocation
- Introducing a continuous-time framework, solving the HJB equation and the classical Merton problem.

401-4889-00L Mathematical Finance W 10 credits 4V+2U B. Acciaio

Abstract
Advanced course on mathematical finance:
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- additional topics

Objective
Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes).

Content
This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- and probably others

Lecture notes
The course is based on different parts from different books as well as on original research literature.

Lecture notes will not be available.

Literature
While there are many textbooks on mathematical finance, none of them is ideal to cover the contents of this course. References include the following books:


Competencies
Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

Method-specific Competencies
- Probability Theory (for which lecture notes are available)
- Brownian Motion and Stochastic Calculus (for which lecture notes are available)
- Those students who already attended "Introduction to Mathematical Finance" will have an advantage in terms of ideas and concepts.

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

103-0227-00L Application Development in Cartography W 6 credits 4G A. Neumann

Abstract
This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

Objective
Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.
Geoinformationstechnologien und -analysen für Fortgeschrittene: Mobile GIS; Web-GIS & Geo-Web-Services; Spatial Big Data; Zeitliche Aspekte in GIS; Analyse von Bewegungsdaten; Benutzerschnittstellen

Übungen: Web-GIS-Semesterprojekt in Gruppenarbeit - die Übungen finden auf Englisch statt!


Geoinformationstechnologien und -analysen für Fortgeschrittene: Mobile GIS; Web-GIS & Geo-Web-Services; Spatial Big Data; Zeitliche Aspekte in GIS; Analyse von Bewegungsdaten; Benutzerschnittstellen

Independent study project with novel geoinformation technologies. Information on past projects: http://gis-lab.ethz.ch/

This lab focuses on presenting spatial, temporal, and open data in tangible ways. Students will learn how to work with novel geoinformation technologies such as virtual/mixed reality or mobile applications. They will engage in teamwork, application design, programming and presenting their results.

Building a Robot Judge: Data Science for Decision-Making

Does not take place this semester.
Particularly suitable for students of D-INFK, D-ITET, D-MTEC.

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will be introduced to emerging applied research in this vein. In a seminar paper, students (individually or in groups) will conceive and implement an applied data-science research project.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a seminar paper, students (individually or in groups) will conceive and implement an applied data-science research project.

851-0735-09L Workshop & Lecture Series on the Law & Economics of Innovation W 2 credits 2S S. Bechtold

Abstract
This series is a joint project by ETH Zurich and the Universities of St. Gallen and Zurich. It provides an overview of interdisciplinary research on intellectual property, innovation, antitrust, privacy & technology policy. Scholars from law, economics, management and related fields present their current research. All speakers are internationally well-known experts from Europe, the U.S. & beyond.

Objective
After the workshop and lecture series, participants should be acquainted with interdisciplinary approaches towards intellectual property, innovation, antitrust, privacy and technology policy research. They should also have an overview of current topics of international research in these areas.

Content
The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods applied to intellectual property, innovation, antitrust, privacy and technology policy issues. In particular, theoretical models, empirical and experimental research as well as legal research methods will be represented.

Lecture notes
Papers discussed in the workshop and lecture series are posted in advance on the course web page.

Literature
Suzanne Scotchmer, Innovation and Incentives, 2004
Bronwyn Hall / Nathan Rosenberg (eds.), Handbook of the Economics of Innovation, 2 volumes, Amsterdam 2010

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed
Social Competencies: Communication assessed
Personal Competencies: Creative Thinking assessed
Critical Thinking assessed

227-0421-00L Learning in Deep Artificial and Biological Neuronal Networks W 4 credits 3G B. Grewe

Abstract
Deep-Learning (DL) is a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological neurons might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective
The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Content
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind what humans can achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes
The lecture slides will be provided as a PDF after each lecture.
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties

V. Mante

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits,

dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are

accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on

physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation,

learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak

inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of

high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of

neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological

neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below

and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance

amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and

an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory

sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice
Particular: The course is highly recommended for those who intend to take the spring semester course 'Neuromorphic Engineering II', that

teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Neuromorphic Engineering I

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits,

dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are

accompanied by weekly laboratory sessions.

Introduction to Neuroinformatics

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties

(action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and

behavior will be explained. Some artificial systems (robot, chip) are presented.

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can

contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the

monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the

enchancements and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to
discovering solutions.

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies

fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell

needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical

current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active

properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along

axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and

topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow

across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitory

neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures

of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor

information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological

basis of computations in neurons.

Systems Neuroscience (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI415

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract
This course focuses on basic aspects of central nervous system physiology, including perception, motor control and cognitive functions.

Objective
To understand the basic concepts underlying perceptual, motor and cognitive functions.

Content
Main emphasis sensory systems, with complements on motor and cognitive functions.

Literature
"Principles of Neural Science", Kandel, Schwartz, and Jessel
Network Analysis

Particularly suitable for students of D-INFK, D-MATH.

W  3 credits  2V  U. Brandes

Abstract
Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Objective
Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

Content
The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

* Empirical Research and Network Data
* Macro and Micro Structure
* Centrality
* Roles
* Cohesion
* Influence

Lecture notes
Slides and lecture notes are distributed via the associated course moodle.

Literature

Competencies
Subject-specific Competencies

Concepts and Theories fostered

Techniques and Technologies assessed

Analytical Competencies assessed

Decision-making fostered

Problem-solving assessed

Communication fostered

Self-presentation and Social Influence fostered

Sensitivity to Diversity fostered

Adaptability and Flexibility fostered

Creative Thinking assessed

Critical Thinking assessed

Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered

Network Modeling

Particularly suitable for students of D-MATH, D-INFK and in the MSc Data Science

W  3 credits  2G  C. Stadtfeld, I. Smokovic, A. Uzaheta Berdugo

Abstract
Social Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks, including statistical and mathematical methods. In this course, the emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective
The following topics will be covered:

- Introduction to network models and their applications
- Stylized models:
  * uniform random graph models
  * small world models
  * preferential attachment models
- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)
- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems.

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

**Objective**
Network science as a paradigm is entering domains from engineering to the humanities but application is tricky. By examples from recent research on sports analytics, students learn to appreciate that, and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.

**Prerequisites / notice**
Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

**Literature**
Abstract

This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based simulation models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in groups.

Objective

At the end of the course, the students should:
- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform transportation studies

Content

This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zürich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained. Here the open source eqasim framework used at ETH Zürich to set up agent-based models will be introduced
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

Literature

Agent-based modeling in general

MATSim


Prerequisites / notice

There are no strict prerequisites regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

For those without object-oriented programming experience, a crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

Competencies

Subject-specific Competencies
- Techniques and Technologies
  - assessed
Method-specific Competencies
- Analytical Competencies
  - fostered
- Problem-solving
  - assessed
- Project Management
  - fostered
Social Competencies
- Cooperation and Teamwork
  - fostered
Personnel Competencies
- Critical Thinking
  - assessed

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0023-00L</td>
<td>Atmosphere</td>
<td>3</td>
<td>W. E. Fischer, U. Lohmann</td>
</tr>
</tbody>
</table>

Abstract

Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Objective

Students are able
- to explain the physical structure and chemical composition of the atmosphere
- to quantitatively describe and understand the fundamental physical and chemical process in the atmosphere
- to explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.

In the course "Atmosphere", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined.

Content

Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds.

Lecture notes

Written information will be supplied.

Lecturer notes


Competencies

Subject-specific Competencies
- Concepts and Theories
  - assessed
- Analytical Competencies
  - assessed
- Decision-making
  - fostered
- Problem-solving
  - assessed
Social Competencies
- Communication
  - fostered
- Cooperation and Teamwork
  - fostered
- Sensitivity to Diversity
  - fostered
Personal Competencies
- Critical Thinking
  - fostered
- Self-awareness and Self-reflection
  - fostered

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Lecturer(s)</th>
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</thead>
<tbody>
<tr>
<td>701-0473-00L</td>
<td>Weather Systems</td>
<td>3</td>
<td>M. A. Sprenger, I. Thurnherr</td>
</tr>
</tbody>
</table>

Abstract

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situtations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

Objective

The students are able to
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of stable water isotopes as tracers for moist diabatic processes in weather systems

Content

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situtations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

Lecture notes

Lecture notes and slides
The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments, often shared with humans and other robots, is a difficult problem combining discrete and continuous mathematics, as well as probabilistic, game-theoretic, and ethical/regulatory aspects. This course will cover the algorithmic foundations of motion planning, with an eye to real-world implementation issues.

Objective

The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments.

Content


Lecture notes

Course notes and other education material will be provided for free in an electronic form.

Literature

There is no required textbook, but an excellent reference is Steve Lavalle's book on "Planning Algorithms."
Prerequisites / Competencies

Students should have taken basic courses in optimization, control systems, probability theory, and should be familiar with modern programming languages and practices (e.g., Python, and/or C/C++). Previous exposure to robotic systems is a definite advantage.

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Decision-making

Problem-solving

151-0563-01L Dynamic Programming and Optimal Control

Dynamic Programming and Optimal Control

Index to Dynamic Programming and Optimal Control.

Objectives

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature


Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

151-0632-00L Vision Algorithms for Mobile Robotics (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: DINF2039

Abstract

Mind the enrolment deadlines at UZH:

https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Objectives

For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry. The algorithms behind Hololens, Oculus Quest, and the NASA Mars rovers will be introduced.

Content

Each lecture will be followed by a lab session where you will learn to implement a building block of a visual odometry algorithm in Matlab.

By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.

Lecture Notes

Lecture slides will be made available on the course official website: http://rpg.ifi.uzh.ch/teaching.html

Literature


Prerequisites / Notice

Fundamentals of algebra, geometry, matrix calculus, and Matlab programming.

Note: If you are interested in taking UZH courses, you must register as an incoming mobility student at UZH. For details, see as follows:

UZH course enrollment for ETH student at University of Zurich (UZH) > Mobility within Switzerland – Incoming > Module Mobility: The easiest way to take individual modules/courses to supplement your studies at your home university is with module mobility. This option is not available to students who have dropped out of their home university or have been definitely excluded or banned from the relevant a program > Application and Deadlines: Applications are submitted via the UZH application portal (https://www.uzh.ch/cmsssl/en/studies/application/chiMobility.html)

Step-by-step guidelines on how ETH students can register for this course, are given on the official course website:

https://rpg.ifi.uzh.ch/teaching.html

ATTENTION: When you book the course at UZH, you are automatically registered for the exam at UZH and you can unregister until the October deadline. After registering for the course, you as an ETH student need to check out your "UZH email account" to receive the related information from the lecturer.

151-0851-00L Robot Dynamics

Robot Dynamics

We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

The course consists of three parts: First, we will refresh and deepen the student's knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will be upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

Prerequisites / Notice

227-0103-00L Control Systems

Control Systems

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Abstract

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.
Content


Literature


Prerequisites / notice

Prerequisites: Signal and Systems Theory II.
MATLAB is used for system analysis and simulation.

Additional Electives

- All courses on master's level from D-INFK, D-ITET and D-MATH
- All courses listed in the Interdisciplinary Electives

Data Science Lab

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>263-3300-10L</td>
<td>Data Science Lab</td>
<td>O</td>
<td>10 credits</td>
<td></td>
<td>A. Ilic, V. Boeova, R. Cotterell, J. Vogt, F. Yang</td>
</tr>
</tbody>
</table>

Abstract

In this class, we bring together data science applications provided by ETH researchers outside computer science and teams of computer science master's students. Two to three students will form a team working on data science/machine learning-related research topics provided by scientists in a diverse range of domains such as astronomy, biology, social sciences etc.

Objective

The goal of this class if for students to gain experience of dealing with data science and machine learning applications "in the wild". Students are expected to go through the full process starting from data cleaning, modeling, execution, debugging, error analysis, and quality/performance refinement.

Prerequisites / notice

Prerequisites: At least 8 KP must have been obtained under Data Analysis and at least 8 KP must have been obtained under Data Management and Processing.

Master Studies (Programme Regulations 2017)

Core Courses

Data Analysis

Information and Learning

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

- Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

- Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.
Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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<tbody>
<tr>
<td>401-3621-00L</td>
<td>Fundamentals of Mathematical Statistics</td>
<td>W</td>
<td>9 credits</td>
<td>4V+1U</td>
<td>J. Ziegel</td>
</tr>
</tbody>
</table>

Abstract

In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

Objective

The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.

Competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Problem-solving

Personal Competencies

Creative Thinking

Prerequisites / notice

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

Statistics

Data Management

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-4500-00L</td>
<td>Advanced Algorithms</td>
<td>W</td>
<td>9 credits</td>
<td>3V+2U+3A</td>
<td>J. Lengler, B. Häupler, M. Probst</td>
</tr>
</tbody>
</table>

Abstract

This is a graduate-level course on algorithm design (and analysis). It covers a range of topics and techniques in approximation algorithms, sketching and streaming algorithms, and online algorithms.

Objective

This course familiarizes the students with some of the main tools and techniques in modern subareas of algorithm design.

Content

The lectures will cover modern topics in algorithm design and analysis, including the following: graph sparsifications while preserving cuts or distances, various approximation algorithms techniques and concepts, metric embeddings and probabilistic tree embeddings, online algorithms, multiplicative weight updates, streaming algorithms, sketching algorithms.

Lecture notes

https://people.inf.ethz.ch/~aroeyskoe/AA23

Prerequisites / notice

This course is designed for masters and doctoral students and it especially targets those interested in theoretical computer science, but it should also be accessible to last-year bachelor students.

Sufficient comfort with both (A) Algorithm Design & Analysis and (B) Probability & Concentrations. E.g., having passed the course Algorithms, Probability, and Computing (APC) is recommended, though not required formally. If you are not sure whether you're ready for this class or not, please consult the instructor.

Competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Decision-making

Problem-solving

Data Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>263-3010-00L</td>
<td>Big Data</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>G. Fourny</td>
</tr>
</tbody>
</table>
Abstract

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

Content

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Literature

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 687 of 2667
263-3845-00L Data Management Systems W 8 credits 3V+1U+3A G. Alonso

Abstract
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Objective
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place a special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Literature
The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

Prerequisites / notice
The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

Core Electives

Number Title Type ECTS Hours Lecturers
151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D’Andrea

227-0101-00L Discrete-Time and Statistical Signal Processing W 6 credits 4G H.-A. Loeliger

227-0417-00L Information Theory I W 6 credits 4G A. Lapidoth

227-0560-00L Computer Vision and Artificial Intelligence for Autonomous Driving W 6 credits 3V+2P C. Sakaridis

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 688 of 2667
Abstract
This course introduces the core computer vision techniques and algorithms that autonomous cars use to perceive the semantics and geometry of their driving environment, localize themselves in it, and predict its dynamic evolution. Emphasis is placed on techniques tailored for real-world settings, such as multi-modal fusion, domain-adaptive and outlier-aware architectures, and multi-agent methods.

Objective
Students will learn about the fundamentals of autonomous cars and of the computer vision models and methods these cars use to analyze their environment and navigate themselves in it. Students will be presented with state-of-the-art representations and algorithms for semantic, geometric and temporal visual reasoning in automated driving and will gain hands-on experience in developing computer vision algorithms and architectures for solving such tasks.

After completing this course, students will be able to:
1. understand the operating principles of visual sensors in autonomous cars
2. differentiate between the core architectural paradigms and components of modern visual perception models and describe their logic and the role of their parameters
3. systematically categorize the main visual tasks related to automated driving and understand the primary representations and algorithms which are used for solving them
4. critically analyze and evaluate current research in the area of computer vision for autonomous cars
5. practically reproduce state-of-the-art computer vision methods in automated driving
6. independently develop new models for visual perception

Content
The content of the lectures consists in the following topics:

1. Fundamentals
   (a) Fundamentals of autonomous cars and their visual sensors
   (b) Fundamental computer vision architectures and algorithms for autonomous cars

2. Semantic perception
   (a) Semantic segmentation
   (b) Object detection
   (c) Instance segmentation and panoptic segmentation

3. Geometric perception and localization
   (a) Depth estimation
   (b) 3D reconstruction
   (c) Visual localization
   (d) Unimodal visual/lidar 3D object detection

4. Robust perception: multi-modal, multi-domain and multi-agent methods
   (a) Multi-modal 2D and 3D object detection
   (b) Visual grounding and verbo-visual fusion
   (c) Domain-adaptive and outlier-aware semantic perception
   (d) Vehicle-to-vehicle communication for perception

5. Temporal perception
   (a) Multiple object tracking
   (b) Motion prediction

The practical projects involve implementing complex computer vision architectures and algorithms and applying them to real-world, multi-modal driving datasets. In particular, students will develop models and algorithms for:
1. Semantic segmentation and depth estimation
2. Sensor calibration for multi-modal 3D driving datasets
3. 3D object detection using lidars

Lecture notes
Lecture slides are provided in PDF format.

Prerequisites / notice
Students are expected to have a solid basic knowledge of linear algebra, multivariate calculus, and probability theory, and a basic background in computer vision and machine learning. All practical projects will require solid background in programming and will be based on Python and libraries of it such as PyTorch.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed

Method-specific Competencies
Analytical Competencies
Assessed

Social Competencies
Communication
Cooperation and Teamwork
fostered

Personal Competencies
Creative Thinking
Critical Thinking
assessed

System Identification
W 4 credits 2V+1U R. Smith

Abstract
Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.

Objective
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Closed-loop identification strategies. Trade-off between controller performance and information available for identification.


Literature
Additional papers will be available via the course Moodle.

Prerequisites / notice
Control systems (227-0216-00L) or equivalent.

Computer Architecture
W 8 credits 6G+1A S. Sadrosadati, O. Mutlu

Abstract
Autumn Semester 2024

Objective
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Closed-loop identification strategies. Trade-off between controller performance and information available for identification.


Literature
Additional papers will be available via the course Moodle.

Prerequisites / notice
Control systems (227-0216-00L) or equivalent.
Abstract
Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic concepts of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective
We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content
The first part of the course covers general security concepts and hardware-based support for security. The second part, the focus is on system design and methodologies for building secure systems.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Social Competencies
- Communication assessed
- Leadership and Responsibility assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Critical Thinking assessed
- Self-direction and Self-management assessed

Prerequisites / notice

Lecture notes
All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

Literature
We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

See https://safari.ethz.ch/architecture for past examples.

252-1414-00L System Security

Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Problem-solving fostered

Social Competencies
- Communication fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered

252-3005-00L Natural Language Processing

Abstract
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary research areas in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

261-5130-00L Research in Data Science

Abstract
Independent work under the supervision of a core or adjunct faculty of data science.

Objective
Independent work under the supervision of a core or adjunct faculty of data science.

Prerequisites / notice
Only students who have passed at least one core course in Data Management and Processing, and one core course in Data Analysis can start with a research project.

A project description must be submitted at the start of the project to the studies administration.
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of the fundamental objectives of this course. Students learn how to solve algorithmic problems given by a textual description. This includes appropriate problem modeling, choice of suitable (combinatorial) algorithms, and implementing them (using C/C++, STL, OGAL, and BGL).

The objective of this course is to learn how to solve algorithmic problems given by a textual description. This includes appropriate problem modeling, choice of suitable (combinatorial) algorithms, and implementing them (using C/C++, STL, OGAL, and BGL).

**Literature**


**Prerequisites / notice**

Ideally, students will have taken the D-INFK Bachelors course "Information Security" or an equivalent course at Bachelor's level. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets. The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Problem-solving
- **Personal Competencies**
  - Adaptability and Flexibility

**Literature**


**Prerequisites / notice**

Ideally, students will have taken the D-INFK Bachelors course "Information Security" or an equivalent course at Bachelor's level. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets. The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Problem-solving
- **Personal Competencies**
  - Adaptability and Flexibility

**Literature**


**Prerequisites / notice**

Ideally, students will have taken the D-INFK Bachelors course "Information Security" or an equivalent course at Bachelor's level. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets. The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Problem-solving
- **Personal Competencies**
  - Adaptability and Flexibility

**Literature**


**Prerequisites / notice**

Ideally, students will have taken the D-INFK Bachelors course "Information Security" or an equivalent course at Bachelor's level. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets. The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Problem-solving
- **Personal Competencies**
  - Adaptability and Flexibility
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folkore.

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

This is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallelle Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is to develop a profound understanding of these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  Advanced Machine Learning  
  https://mi2.informatik.ethz.ch/courses/am/

  Computational Intelligence Lab  
  http://da.inf.ethz.ch/teaching/2019/CIL/

  Introduction to Machine Learning  
  https://las.inf.ethz.ch/teaching/introml-S19

  Statistical Learning Theory  
  http://mi2.informatik.ethz.ch/courses/slt/

  Computational Statistics  
  https://stat.ethz.ch/lectures/ss19/comp-stats.php

  Probabilistic Artificial Intelligence  
  https://las.inf.ethz.ch/teaching/pai-f18

Artificial Intelligence in Education

Objective: The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.

Content: The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student-facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to individually prepare on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture notes: Lecture slides will be made available at the course Web site.

Literature: No textbook is required, but there will be regularly assigned readings from literature, linked to the course website.

Probabilistic Artificial Intelligence

Objective: This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Content: Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice: There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.
The objectives of this course are:

1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

**Abstract**

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- **Social Competencies**
  - Communication

- **Personal Competencies**
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics

**Prerequisites / notice**

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression” / “Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

**Objective**

By the end of the semester students should be able to

1. To understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
2. To critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
3. To outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
4. To effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

**Content**

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- Concentration bounds
- Uniform convergence and empirical process theory
- Regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- High-dimensional learning
- Computational and statistical learnability (information-theoretic, PAC, SQ)
- Overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- How overparameterized models generalize (statistically) and converge (computationally)
- Complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- Generalization of robust learning (adversarial or distribution-shift robustness)
- Private and fair learning

**Prerequisites / notice**

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts

- Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

**Objective**

Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.
Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Competencies
Subject-specific Competencies: Concepts and Theories
Techniques and Technologies
Method-specific Competencies: Analytical Competencies
Decision-making
Personal Competencies: Critical Thinking

401-3601-00L Probability Theory
At most one of the three course units (Bachelor Core Courses)
401-3641-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.
Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

Abstract
Basics of probability theory and the theory of stochastic processes in discrete time

Objective
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

Content
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

Lecture notes
will be available in electronic form.

Literature
H. Bauer, Probability Theory, De Gruyter 1996
J. Jacod and P. Protter, Probability essentials, Springer 2004
A. Klenke, Wahrscheinlichkeitstheorie, Springer 2006
D. Williams, Probability with martingales, Cambridge University Press 1991

Prerequisites / notice
- Measure Theory
- Basic notions in probability theory (probability space, conditional probability, Borel Cantelli, Dynkin Lemma, random variables, expectation, variance, law of large numbers).

Competencies
Subject-specific Competencies: Concepts and Theories
Techniques and Technologies
Personal Competencies: Creative Thinking

401-3612-00L Stochastic Simulation
This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

Abstract
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

Content
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

Lecture notes
A script will be available in English.

Literature


Prerequisites / notice
Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

401-3627-00L High-Dimensional Statistics
Does not take place this semester.

Abstract
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

Objective
Knowledge of methods and basic theory for high-dimensional statistical inference.
**Content**
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

**Literature**

**Prerequisites / notice**
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

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**401-3622-00L**

**Statistical Modelling**

**W** 7 credits 4G M. Kalisch

**Abstract**
In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

**Objective**
Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

**Content**

**Prerequisites / notice**
Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden). This is the course unit with former course title "Regression".

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**401-3901-00L**

**Linear & Combinatorial Optimization**

**W** 10 credits 4V+2U R. Zenklusen

**Abstract**
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**

**Prerequisites / notice**
Solid background in linear algebra.

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**401-4944-20L**

**Mathematics of Data Science**

**W** 8 credits 3V+2U A. Bandeira

**Abstract**
Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

**Objective**
Introduction to various mathematical aspects of Data Science.

**Content**
These topics lie in overlaps of Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Most lectures will feature Mathematical Open Problems. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

**Lecture notes**

**Prerequisites / notice**
The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.
A. Bandeira and H. Bölcskei
The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, and assessing W2G. 5 credits

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

The course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Basic knowledge in probability and statistics.

ARMA, ARIMA, Introduction into GARCH models.

Spectral analysis, spectral densities

Elimination of seasonality

Autocorrelation

Trend estimation

Spectral analysis, spectral densities

Forecasting

ARIMA, ARIMA Introduction to GARCH models

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Objective
After this course, you should be able to
- understand the language and concepts of causal inference
- know the assumptions under which one can infer causal relations from observational and/or interventional data
- describe and apply different methods for causal structure learning
- given data and a causal structure, derive causal effects and predictions of interventional experiments

Content
The material covered in this course has a significant overlap with the material that has been covered in 401-3620-22L Student Seminar in Statistics: Causality FS2023.

Literature
Parts of this course will be based on the book "Elements of Causal Inference" (MIT Press, open access). More details will follow.

Prerequisites / notice
Prerequisites: basic knowledge of probability theory and regression

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

402-0448-01L Quantum Information Processing I: Concepts
This theory part QIP I together with the experimental part 402-0448-02L QIP II (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in Physics.

Abstract
The course covers the key concepts and formalism of quantum information processing. Topics include quantum algorithms, quantum error correction, quantum cryptography, and quantum metrology, with an emphasis on the power of quantum information processing beyond that of classical information processing. The formalism of quantum states, measurements, and channels is developed in detail.

Objective
By the end of the course students are able to explain the basic mathematical formalism of quantum mechanics and apply it to quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

Content
The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum circuits, quantum algorithms (Shor, Grover, Deutsch-Josza,...), stabilizer-based quantum error correction, fault-tolerant designs, the BB84 quantum key distribution protocol, and simple methods of quantum metrology.

Lecture notes
Will be provided.

Literature
Quantum Computation and Quantum Information
Michael Nielsen and Isaac Chuang
Cambridge University Press

Prerequisites / notice
A good understanding of finite dimensional linear algebra is recommended.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered

Interdisciplinary Electives
Interdisciplinary Electives

Data Science Lab

Number Title Type ECTS Hours Lecturers
263-3300-00L Data Science Lab O 14 credits 9P A. Ilie, V. Boeva, R. Cotterell, J. Vogt, F. Yang

Abstract
In this class, we bring together data science applications provided by ETH researchers outside computer science and teams of computer science master's students. Two to three students will form a team working on data science/machine learning-related research topics provided by scientists in a diverse range of domains such as astronomy, biology, social sciences etc.

Objective
The goal of this class if for students to gain experience of dealing with data science and machine learning applications "in the wild". Students are expected to go through the full process starting from data cleaning, modeling, execution, debugging, error analysis, and quality/performance refinement.

Prerequisites / notice
Prerequisites: At least 8 KP must have been obtained under Data Analysis and at least 8 KP must have been obtained under Data Management and Processing.

Seminar

Number Title Type ECTS Hours Lecturers
252-5051-00L Advanced Topics in Machine Learning W 2 credits 2S R. Cotterell, M. El-Assady, N. He, F. Yang

Abstract
In this seminar, recent papers of the pattern recognition and machine learning literature are presented and discussed. Possible topics cover statistical models in computer vision, graphical models and machine learning.
The seminar "Advanced Topics in Machine Learning" familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper. An important goal of the seminar presentation is to summarize the essential ideas of the paper in sufficient depth while omitting details which are not essential for the understanding of the work. The presentation style will play an important role and should reach the level of professional scientific presentations.

The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.

All other students: read the paper and submit questions they have about the paper before the presentation.

Reviewer: Perform a critical review of the paper.

Presenter: Give a presentation about the paper that you read in depth.

Registered after that date, but do not attend the seminar, will officially fail the seminar.

The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

This seminar discusses recent relevant contributions to the fields of medical machine learning and related areas. Each participant will hold a presentation and lead the subsequent discussion.

Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize it for presentation to an audience. The necessary skills to successfully present the key points of existing research work are the same as those needed to communicate own research ideas. In addition to holding a presentation, each student will both contribute to as well as lead a discussion section on the topics presented in the class.

The topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.

The necessary background in systems and low level programming.

Students taking this seminar should have the necessary background in systems and low level programming.

The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

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The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

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### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>261-0800-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

The minimal prerequisites for the Master's thesis registration are:

- Completed Bachelor's program
- All additional requirements completed (additional requirements, if any, are listed in the admission decree)
- Minimum degree requirements fulfilled of the course categories Data Analysis and Data Management and overall 50 credits obtained in the course category Core Courses
- Data Science Lab (14 credits) completed

**Abstract**
The Master's thesis concludes the study program and demonstrates the students' ability to use the knowledge and skills acquired during Master's studies to solve a complex data science problem.

**Objective**
To work independently and to produce a scientifically structured work.

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### Data Science Master - Key for Type

<table>
<thead>
<tr>
<th>Dr</th>
<th>Suitable for doctorate</th>
<th>W</th>
<th>Eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</table>

**ECTS**
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Subject Specialisation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0015-00L</td>
<td>Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>B. Vienni Baptista, C. E. Pohl, M. Stauffacher</td>
</tr>
</tbody>
</table>

**Abstract**
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societal relevant.

**Objective**
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, or how to secure broader impact of research. They learn to critically reflect their own research project in its societal context and on their role as scientists.

**Content**
The seminar covers the following topics:
1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

**Literature**
Literature will be made available to the participants.

Further, this collection of tools will be used:
- https://naturalsciences.ch/topics/co-producing_knowledge
- https://www.shapeidtoolkit.eu

**Prerequisites / notice**
Participation in the course requires participants to be working on their own research project.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>101-0139-00L</td>
<td>Scientific Machine and Deep Learning for Design and Construction</td>
<td>W+</td>
<td>3</td>
<td>4G</td>
<td>B. Bickel, A. Müller, M. Piovarci</td>
</tr>
</tbody>
</table>

**Abstract**
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

**Objective**
This course aims to provide a graduate-level introduction to machine learning, with a particular focus on scientific machine learning for applications in the design and construction phases of projects from architecture and civil engineering.

Upon completion of the course, the students will be able to:
1. Understand main ML background theory and methods.
2. Assess a problem and apply ML and DL in a computational framework accordingly.
3. Incorporate scientific domain knowledge in the SciML process.
4. Define, plan, conduct and present a SciML project.

**Content**
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
2. Incorporation of Domain Knowledge into ML and DL.
4. ML training, validation and testing pipelines for academic and research projects.

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

**Lecture notes**
The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

**Literature**
Suggested Reading:
- Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
- S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016

**Prerequisites / notice**
Familiarity with Python is advised.
### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>fostered</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td></td>
<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<td>Critical Thinking</td>
<td>fostered</td>
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<td>Self-direction and Self-management</td>
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### 351-0778-00L Discovering Management

**W** 3 credits 3G B. Clarysse, S. Brusoni, V. Hoffmann, T. Netland

**Abstract**

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

**Objective**

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:

1. Broaden understanding of management principles and frameworks
2. Advance insights into the sources of corporate and entrepreneurial success
3. Develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and/or appreciate the challenges that entrepreneurs and managers deal with.

**Content**

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practical sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

### Competencies

<table>
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<td>fostered</td>
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</table>

### 351-0778-01L Discovering Management (Pitch)

**W** 1 credit 1U B. Clarysse, L. P. T. Vandeweghe

**Abstract**

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

**Objective**

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

**Content**

The exercise consists of delivering and submitting a "pitch" with a clear recommendation for one of the selected cases amongst those seen in Discovering Management, using your insights from Discovering Management, and an extra session on pitching.

Students have the option to either do this alone or in a group of two students.

**Literature**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

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Competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies fostered

Method-specific Competencies

- Analytical Competencies assessed
- Media and Digital Technologies fostered
- Problem-solving assessed

Social Competencies

- Communication assessed

Personal Competencies

- Critical Thinking assessed
- Self-direction and Self-management fostered

Media and Digital Technologies

- Problem-solving fostered

Techniques and Technologies

- Decision-making assessed
- Media and Digital Technologies fostered

Analytical Competencies

- Media and Digital Technologies fostered

Critical Thinking

- Self-Direction and Self-management fostered

Problem-solving

- Project Management fostered

Communication

- Cooperation and Teamwork assessed
- Customer Orientation fostered

Self-presentation and Social Influence

- Sensitivity to Diversity assessed

Leadership and Responsibility

- Negotiation assessed

Adaptability and Flexibility

- Critical Thinking assessed

Creative Thinking

- Integrity and Work Ethics assessed

Self-Direction and Self-management fostered

Autumn Semester 2024

064-0005-24L Advanced Topics in History and Theory of Architecture

W 1 credit 1K

Assessed

T. Avermaete, M. Delbeke, L. Stalder, P. Ursprung

Abstract

The seminar will consist of a series of collective readings of selected texts.

Objective

Knowledge of relevant texts in contemporary theory.

Capacity to critically discuss methods and discourses.

Lecture notes

Scans of selected texts for discussion and exercises will be provided at the beginning of the semester on the course website:

https://doctoral-program.gta.arch.ethz.ch/courses

Prerequisites / notice

The seminar addresses the fellows of the Doctoral Program in History and Theory of Architecture. All other doctoral students of the Faculty of Architecture are welcome.

064-0015-24L PhD Colloquium Theory of Information Technology for Architects

W 2 credits 2K

L. Hovestadt

Abstract

Information technology plays an increasingly important role in research. To meet this challenging development, it is not only important to acquire respective skills, but also to consider and understand information technology in what sets it apart from other gestalts of technics (like mechanics, dynamics, or thermodynamics).

Objective

The aim of this colloquium is to counter an observable tendency, that proportional to the degree in which students master practical skills in computing, they increasingly submit uncritically, in their understanding and framing of problems, to the dictation of schemata and templates implemented by technical systems.

Content

The starting point for this colloquium is to comprehend computing not in terms of skills, but as a literacy which we can experience emerging today. Like in the case of writing as well, computing cannot exhaustively be reduced to either logics, grammar, arithmetics, or analytics.

Rather, computation, if comprehended as a literacy, relates to any of the established categories of learning and raises questions of an architectonic kind. This colloquium draws from the principal richness of cultural forms of knowing and learning and thematizes approaches to formulate a theoretical stance on information technology for architects which is driven by and resting on the actual reality of computability today. In this, it is complementary to those theory courses on technology offered by the historical disciplines at ETH.

Prerequisites / notice

To benefit from this course, you should have a practical affinity to technics, as well as an abstract interest in information technology in its comprehensive cultural context.

064-0013-24L Research Methods in the History and Theory of Architecture

W 2 credits 2S

C. Rachele

Abstract

Introduction to methodological approaches in the history and theory of architecture; presentation and discussion of individual doctoral projects.

Objective

This required two-semester course in the first year of the gta doctoral program combines a traditional doctoral reading seminar with a practical writing workshop geared towards the development of the doctoral plan.
The methodology of humanistic research grows more complex with every academic generation: it presents a thicket of epistemological frameworks rather than a straightforward array of tools. In the omnivorous field of architectural history and theory, the scholar faces yet further possibilities. This course considers the variety of available strategies for the creation of architectural histor(ies) and theor(ies) as an intellectual opportunity distinctive to our discipline. Through close study of a range of historically significant or innovative texts, we will deepen our understanding of how other scholars have structured their work and refine our own research methodologies.

The course, held over two semesters, combines a traditional doctoral theory seminar with a practical writing workshop. We will alternate reading-based discussions with working sessions directed towards the development of the doctoral plan to be submitted at the end of the first year.

The course schedule will be available at the beginning of the semester on the course moodle page.

Please note gta doctoral program courses begin the third week of the semester (the first week of October).

Enrolment in agreement with the lecturer only

Priority is given to PhD students.

A 200 CHF deposit will be charged for the VR Headset. It will be refunded upon the return of the headset on the last day of the course.

Please send a short letter of motivation (max 150 words) to Adam Kiryk: kiryk@arch.ethz.ch
This course explores the concept of "Hybrid Reality," blending digital and physical spaces using VR technologies. Students will learn to digitize spaces, create immersive environments, and design interactive exhibitions.

The goal is to digitize an existing space and use it in virtual reality as a context for further design. During the course, AI tools will be utilized to enhance the photogrammetry 3D scanning process. In the first part of the course, we learn the tools; then we work on architectural VR projects, either in groups or individually. Throughout the course, we will examine VR workflows to create immersive and interactive architectural spaces. At the end of the course, we will present the works in a VR exhibition. Each student receives an Oculus Quest VR headset to work with at home throughout the semester.

Fusions of digital-analog relationships have accompanied us since the very beginning of the digitalization era. The rapidly growing impact of digital technologies on our life necessitates constant adaptation. The course introduces the term "Hybrid Reality," which represents the coexistence of physical and digital spaces. Using state-of-the-art VR technologies, the methodology focuses on immersive, real-time, 1:1 scale space creation, exploring corporeal design, and reinventing conventional methods. Students will learn to digitize physical spaces, create hybrid reality environments, and design interactive exhibitions.

The course “360 – Reality to Virtuality” is interconnected with “3D Scanning and Freeform Modeling”. You must register for both courses. “360 – Reality to Virtuality” and “3D-Modeling” (2x 2 ETCS).

Classroom teaching as 4h block + self-teaching and research at home. Max. number of participants 15 students.

A 200 CHF deposit will be charged for the VR Headset. It will be refunded upon the return of the headset on the last day of the course. If you already have an Oculus Quest 2, you do not need to pay any deposit and can work on your own device.

Please send a short application email (max 150 words) to Adam Kiryk: kiryk@arch.ethz.ch

‘...the possibility of talking about “worlds and knowledges otherwise”. It posits that such ways of decolonial, pluriversal, and more-than-human knowing can offer tools and ways for reimagining and reconstructing local worlds and transcending developmental paradigms of researching and operating.

Researching Otherwise is a call to craft another space for the production of knowledge. It posits that fluid epistemologies that respond to ways of decolonial, pluriversal, and more-than-human knowing can offer tools and ways for reimagining and reconstructing local worlds and transcending developmental paradigms of researching and operating. Rather than rigid and closed epistemologies of knowing the landscape and the urban, this seminar promotes fluid epistemologies that respond to the incommensurabilities, radical alterities and other ways of knowing the environment.

Decolonial thinkers such as Walter Mignolo and Gloria Anzaldúa have proposed for border epistemological border which defines that the knowing subject in the disciplines is not transparent and disincorporated or untouched by the geopolitical configuration of the world in which people and regions have and continue to be ranked and configured racially. It argues for moving away from a one world ontology. Decolonial traditions of researching otherwise. The call for researching otherwise is to deploy methodological tools such as drawing, photographing, sounding and listening, filmmaking, walking, and cartography for not only unearthing and unmasking systems of power and domination but also for researching possible other worlds and for countering the disembodiment of research and the researcher.

The seminar will draw upon readings from a forthcoming publication by the same title. In terms of format, it will alternate between inputs by invited guests, reading and discussion sessions, tutorials, and peer-review. A number of input lectures by invited guests will take the participants of the seminar into ways and methods of researching otherwise. These input lectures will be alternated with thematically organised tutorial sessions and peer-review. The seminar participants can choose to present the work developed during the seminar at the LUS Doctoral Cris vs organised at the end of the semester.

The format will provide an overarching methodological meta-theme, to be defined prior to the event. One external guest critic will be invited. In this case, each presentation will conclude with a discussion round, providing sufficiently detailed feedback for every doctoral candidate.

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Prerequisites / notice

The participants of the seminar will be required to participate in two doctoral colloquiums: on Extended Urbanisation on 20.10 and on Lively Cities on 27.10.

Competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies assessed

Personal Competencies

- Critical Thinking assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Transferable Skills

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 705 of 2667
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Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL Transferable Skills Course III (1 week, with Poster or Talk) Only for doctoral students.

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Objective
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900-0112-DRL Participation in Commission I (min 1 year) Only for doctoral students.

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Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year) Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year) Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

052-0925-24L Ethics and Scientific Integrity for Doctoral Students of D-ARCH

Integration into Scientific Community

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- **Abstract**: Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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**Doctorate Architecture - Key for Type**

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
</tr>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
1. Introduction: Overview of seismic isolation; review of structural dynamics and earthquake engineering principles. Viscoelastic behavior.


4. Behavior of rubber isolators under shear and compression
5. Behavior of rubber isolators under bending
6. Buckling and stability of rubber isolators
7. Code provisions for seismically isolated buildings

**Lecture notes**

The electronic copies of the learning material will be uploaded to ILIAS and available through myStudies. The learning material includes: reading material, and (optional) exercise problems and solutions.

**Literature**

- Dynamics of Structures, Theory and Applications to Earthquake Engineering, 4th edition, Anil Chopra, Prentice Hall, 2017
- Design of seismic isolated structures: from theory to practice, Farzad Naeim and James M. Kelly, John Wiley & Sons, 1999
- Mechanics of rubber bearings for seismic and vibration isolation, James M. Kelly and Dimitrios Konstantinidis, John Wiley & Sons, 2011
- Structural Dynamics and Vibration Problems course, or equivalent, or consent of the instructor. Students are expected to know basic modal analysis, elastic spectrum analysis and basic structural mechanics.
Literature
Suggested Reading:
Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016
O. Martin: Bayesian analysis with python. Packt Publishing Ltd, 2016

Prerequisites / notice
Familiarity with Python is advised.

701-0015-00L Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement

Abstract
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

Objective
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, or how to secure broader impact of research. They learn to critically reflect their own research project in its societal context and on their role as scientists.

Content
The seminar covers the following topics:
(1) Theories and concepts of inter- and transdisciplinary research
(2) The specific challenges of inter- and transdisciplinary research
(3) Collaborating between different disciplines
(4) Engaging with stakeholders
(5) 10 steps to make participants' research projects more societally relevant
Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

Literature
Literature will be made available to the participants.
The following open access article builds a core element of the course:
available at (open access): http://www.ingentaconnect.com/contentone/oekom/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used:
https://naturalsciences.ch/topics/co-producing_knowledge
https://www.shapeidtoolkit.eu

Prerequisites / notice
Participation in the course requires participants to be working on their own research project.
Dates (Wednesdays, 8h15-12h00)

101-0523-15L Frontiers in Machine Learning Applied to Civil, Env. and Geospatial Engineering

Abstract
This doctoral seminar organised by the D-BAUG platform on data science and machine learning aims at discussing recent research papers in the field of machine learning and analyzing the transferability/adaptability of the proposed approaches to applications in the field of civil and environmental engineering (if possible and applicable, also implementing the adapted algorithms).

Objective
Students will
• Critically read scientific papers on the recent developments in machine learning
• Put the research in context
• Present the contributions
• Discuss the validity of the scientific approach
• Evaluate the underlying assumptions
• Evaluate the transferability/adaptability of the proposed approaches to own research
• (Optionally) implement the proposed approaches.
Lecturers
Implementation of AI, ML and XR within current projects from research and practice

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

101-1400-01L Design++ Seminar Series/Kolloquium (autumn semester)  W  1 credit  2S  A. Müller, D. Griego, F. Scotto

Abstract Design++ (Center for Augmented Computational Design in Architecture, Engineering and Construction) is inviting national and international experts from different domains related to AI, ML, and XR within the AEC (Architecture, Engineering, and Construction) domain. The goal of the Seminar Series is to promote the knowledge exchange between academia and industry.

Objective Insight into current projects and new research results in the fields of AI, ML and XR from the AEC domain

Content Implementation of AI, ML and XR within current projects from research and practice

Competencies Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Problem-solving

101-1191-00L Computational Science Zurich Academia Industry Modelling (AIM)  W  2 credits  2S  E. Chatzi

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Competencies Subject-specific Competencies: Concepts and Theories
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Transferable Skills

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<td>900-0112-DRL</td>
<td>Participation in Commission I (min 1 year) Only for doctoral students.</td>
<td>1 credit</td>
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<td>Lecturers</td>
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</table>

**Abstract**
Participation in Commission I (min 1 year). Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Objective**
Only for doctoral students.
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year) W 1 credit 2P Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year) W 2 credits 4P Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

101-5000-00L Ethics and Scientific Integrity for Doctoral Students of D-BAUG W 1 credit 1S C. Sailer

Abstract
This course sensitises doctoral students to ethical issues that may arise during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students are given the opportunity to apply their knowledge and train their newly acquired skills in an interactive, discipline specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. Furthermore, they are encouraged to reflect on their professional role as scientific researchers.

Content
Part I
The self-paced e-learning course consists of several modules:

Module Ethics:
Introduction to moral theory (with emphasis on practical guidance regarding decision making).

Module Ethics in scientific research:
Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module Identification of ethical issues:
A variety of tools and resources that help identify ethical issues are presented and explained.

Module Setting up a strategy:
Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module Making decisions:
Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices or solve ethical dilemmas).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects in the general area of Engineering Sciences. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only. Course

Competencies

<table>
<thead>
<tr>
<th>Competency Type</th>
<th>Competency Description</th>
<th>ECTS</th>
<th>Lecturers</th>
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<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Decision-making</td>
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<td></td>
<td>Problem-solving</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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Integration into Scientific Community

Number Title Type ECTS Hours Lecturers

900-0150-DRL Summer School I (1-3 days) W 1 credit 2K Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

900-0151-DRL Summer School II (1-3 days) W 1 credit 2K Lecturers

Only for doctoral students.

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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>900-0155-DRL</td>
<td>Summer School III (1-3 days, with Poster or Talk)</td>
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<td>2</td>
<td>4K</td>
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<td>Only for doctoral students.</td>
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<tr>
<td>900-0156-DRL</td>
<td>Summer School I (1 week)</td>
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<td>4K</td>
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<tr>
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<tr>
<td>900-0158-DRL</td>
<td>Summer School III (1 week)</td>
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<td>900-0159-DRL</td>
<td>Summer School I (1 week, with Poster or Talk)</td>
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<td>6K</td>
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<tr>
<td>900-0160-DRL</td>
<td>Summer School II (1 week, with Poster or Talk)</td>
<td>W</td>
<td>3</td>
<td>6K</td>
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<td>Only for doctoral students.</td>
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</table>
and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Details</th>
<th>Type</th>
<th>Credit</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>900-0161-DRL</td>
<td><strong>Summer School III (1 week, with Poster or Talk)</strong>&lt;br&gt;Only for doctoral students.</td>
<td>W</td>
<td>3 credits</td>
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<td>W</td>
<td>1 credit</td>
<td>2K Lecturers</td>
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<td>Abstract</td>
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**Doctorate Civil, Environmental and Geomatic Engineering - Key for Type**

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<thead>
<tr>
<th>Code</th>
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<tr>
<td>O</td>
<td>Compulsory</td>
<td>Z</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>W+</td>
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**Key for Hours**

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<td>V</td>
<td>lecture</td>
<td>P</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
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<td>U</td>
<td>exercise</td>
<td>D</td>
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<td>S</td>
<td>seminar</td>
<td>R</td>
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<td>K</td>
<td>colloquium</td>
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**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Subject Specialisation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-1791-00L</td>
<td>Introductory Course in Neuroscience I (University of Zurich)</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>W. Knecht, University lecturers</td>
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</tbody>
</table>

*No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.*

UZH Module Code: SPV0Y005


**Abstract**
The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.

**Objective**
The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.

**Content**
1) Human Neuroanatomy I&II  
2) Comparative Neuroanatomy  
3) Building a central nervous system I,II  
4) Synapses I,II  
5) Glia and more  
6) Excitability  
7) Circuits underlying Emotion  
8) Visual System  
9) Auditory & Vestibular System  
10) Somatosensory and Motor Systems  
11) Learning in artificial and biological neural networks

**Prerequisites / notice**
For doctoral students of the Neuroscience Center Zurich (ZNZ).

<table>
<thead>
<tr>
<th>Number</th>
<th>Rate-Controlled Separations in Fine Chemistry</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0927-00L</td>
<td>Rate-Controlled Separations in Fine Chemistry</td>
<td>W</td>
<td>6</td>
<td>3V+1U</td>
<td>M. Mazzotti, V. Becattini, N. Casas, F. Kiefer</td>
</tr>
</tbody>
</table>

**Abstract**
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

**Objective**
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

**Content**
The class covers separation techniques that are central in the purification and downstream processing of chemicals and biopharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

**Lecture notes**
Handouts during the class

**Literature**
Recommendations for text books will be covered in the class

**Prerequisites / notice**
Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)

**Competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>assessed</th>
<th>fostered</th>
<th>managed</th>
<th>promoted</th>
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<tr>
<td>Subject-specific Competencies</td>
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<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<tr>
<td>Critical Thinking</td>
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<tr>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Self-direction and Self-management</td>
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<tr>
<th>Number</th>
<th>Applied Statistical Regression</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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</table>

**Abstract**
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models; this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

**Lecture notes**
A script will be available.
In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

### Competencies

<table>
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<tr>
<th><strong>401-5640-00L</strong></th>
<th>ZÜKoSt: Seminar on Applied Statistics</th>
<th><strong>E-</strong></th>
<th>0 credits</th>
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<tr>
<td><strong>Abstract</strong></td>
<td>About 3 talks on applied statistics.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>See how statistical methods are applied in practice.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>There will be about 3 talks on how statistical methods are applied in practice.</td>
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<tr>
<td><strong>Competencies</strong></td>
<td>Subject-specific Competencies: Concepts and Theories; Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Method-specific Competencies: Analytical Competencies; Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Social Competencies: Communication</td>
<td>assessed</td>
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<td></td>
<td>Personal Competencies: Adaptable and Flexibility; Critical Thinking</td>
<td>assessed</td>
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<tr>
<th><strong>551-1109-00L</strong></th>
<th>Seminars in Microbiology</th>
<th><strong>E-</strong></th>
<th>0 credits</th>
<th><strong>2K</strong></th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Seminars by invited speakers covering selected microbiology themes.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Discussion of selected microbiology themes presented by invited speakers.</td>
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<table>
<thead>
<tr>
<th><strong>401-0620-00L</strong></th>
<th>Statistical Consulting</th>
<th><strong>E-</strong></th>
<th>0 credits</th>
<th><strong>0.1K</strong></th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The Statistical Consulting service is open for all members of ETH, including students, and partly also to other persons.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Advice for analyzing data by statistical methods.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Students and researchers can get advice for analyzing scientific data, often for a thesis. We highly recommend to contact the consulting service when planning a project, not only towards the end of analyzing the resulting data!</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>This is not a course, but a consulting service. There are no exams nor credits.</td>
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<tr>
<td><strong>Requirements</strong></td>
<td>Knowledge of the basic concepts of statistics is desirable.</td>
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<table>
<thead>
<tr>
<th><strong>551-0512-00L</strong></th>
<th>Current Topics in Molecular and Cellular Neurobiology</th>
<th><strong>W</strong></th>
<th>2 credits</th>
<th><strong>1S</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The course is a literature seminar or &quot;journal club&quot;. Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.</td>
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<tr>
<td><strong>Content</strong></td>
<td>You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance. You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).</td>
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</table>
The students should get familiar with the wide array of roles non-coding RNAs play in cellular functions.

F. Allain fostered 2S fostered 2S fostered

This monthly meeting is a platform for Zurich-based immunology research groups to present and discuss their ongoing research projects.

Students gain competences in presenting their work orally, leading discussions about current topics in ecology and evolution, interacting with colleagues from various subdisciplines, and engaging in critical dialogue about ongoing research projects.

None

For information, location and details: https://pe.ethz.ch/education/zis.html

Competencies

Subject-specific Competencies

Concepts and Theories fostered

Techniques and Technologies fostered

Method-specific Competencies

Analytical Competencies fostered

Decision-making fostered

Problem-solving fostered

Project Management fostered

Social Competencies

Communication assessed

Leadership and Responsibility fostered

Self-presentation and Social Influence fostered

Personal Competencies

Critical Thinking fostered

Self-awareness and Self-reflection fostered

Abstract

This monthly meeting is a platform for Zurich-based immunology research groups to present and discuss their ongoing research projects. At each meeting three PhD students or Postdocs from the participating research groups present an ongoing research project in a 30 min seminar followed by a plenary discussion.

Objective

The aim of this monthly meeting is to provide further education for master and doctoral students as well as Postdocs in diverse topics of immunology and to give an insight in the related research. Furthermore, this platform fosters the establishment of science- and technology-based interactions between the participating research groups.

Content

Presentation and discussion of current research projects carried out by various immunology-oriented research groups in Zurich.

551-1615-00L NMR Methods for Studies of Biological Macromolecules

Prerequisites: Basic knowledge in biological NMR spectroscopy.

In this seminar series, topics relevant to solution state NMR with biological macromolecules are treated. Each semester a different aspect of biomolecular NMR is discussed in depth. The course is tailored to advanced students (PhD students and postdocs) who have experience with applications of NMR spectroscopy. Each participant presents a selected topic in form of a seminar.

The students will actively participate in the course which is held in the form of a seminar. Individual students will prepare particular topics of the course based on literature references and present the material in form of a seminar to their fellow students. In short, the students learn to actively participate in discussions and to prepare a presentation of a scientific topic which was mostly unknown to them before.

Competencies

Subject-specific Competencies

Concepts and Theories fostered

Techniques and Technologies fostered

Analytical Competencies fostered

Media and Digital Technologies fostered

Social Competencies

Communication fostered

Cooperation and Teamwork fostered

Customer Orientation fostered

Sensitivity to Diversity fostered

Personal Competencies

Adaptability and Flexibility fostered

Creative Thinking fostered

Critical Thinking fostered

Integrity and Work Ethics fostered

Self-direction and Self-management fostered

Abstract

This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

Objective

The students should obtain an understanding of these processes, which are at work during gene expression.
Subject-specific Competencies

In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similar to emulsions.

This interdisciplinary course encompasses milestone works and cutting-edge research questions in the young field of biomolecular condensates, including their properties, functions, and applications. The course begins with a lecture series that introduces the topic of condensates to an interdisciplinary audience and provides a theoretical foundation for understanding current research questions in the field. The lectures provide a base for student presentations of recent publications in the field, and for research seminars given by course lecturers, who are all active researchers with diverse expertise. Through this exciting interdisciplinary understanding of biomolecular condensates, bridging biology, chemistry, biophysics, and soft matter.

Students will not only learn how to critically read and evaluate scientific literature but will also gain valuable experience in giving scientific presentations to an interdisciplinary audience. Each presentation will require an introduction, critical analysis of the results, and a discussion of their significance, allowing student to substantiate their statements with a critical mindset that considers the pros and cons of chosen approaches and methods, as well as any limitations or possible follow-up experiments. This process will enable student to ask relevant queries and actively participate in class discussions, further enhancing their scientific skills.

In preparing the presentations, the students will have the unique opportunity to interact closely with each other and with the lecturers, who are all internationally well-established experts, and receive guidance in selectin a topic for the final presentation and supporting literature.
The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and requires a multi-disciplinary approach that leverages and cross-fertilizes biology, physical chemistry, biophysics, and soft matter. This course will explore the properties, functions and potential applications of biomolecular condensates, including their role in neurodegenerative diseases such as Alzheimer's and Parkinson's, as well as their use as smart biomimetic materials.

This course is divided into two parts. The first part will introduce the basic concepts essential to the study of biomolecular condensates and phase separation. Topics include: fundamental units and scales in soft matter, phase transitions in biology, biopolymers and molecular self-assembly, introduction to active matter. This will establish a foundation for the second part, which will explore milestone works and current research in the field of biomolecular condensates. Each lecture of this second part will consist of:
1) a short literature seminar, where student groups will present and discuss a milestone paper assigned in advance and
2) a research seminar, where one of the course lecturers will present their own state-of-the-art research in the field, building upon the milestone literature.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Lecture notes
Lecture slides and some scripts will be provided.

Literature
No compulsory textbooks. Literature will be provided during the course

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving fostered
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation fostered
- Leadership and Responsibility assessed
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity assessed
- Negotiation assessed

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Transferable Skills

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<td>900-0100-DRL</td>
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<td>W</td>
<td>1 credit</td>
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Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

| 900-0101-DRL  | Transferable Skills Course II (1-3 days)                            | W    | 1 credit | 2S    | Lecturers |

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

| 900-0102-DRL  | Transferable Skills Course III (1-3 days)                           | W    | 1 credit | 2S    | Lecturers |

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

| 900-0103-DRL  | Transferable Skills Course I (1-3 days, with Poster or Talk)        | W    | 2 credits | 4S    | Lecturers |

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
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Educational Science for Teaching Diploma and TC
Language Courses ETH/UZH: see Science in Perspective
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Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
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Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL Participation in Commission I (min 1 year)

W 1 credit 2P Lecturers

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year)

W 1 credit 2P Lecturers

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year)

W 2 credits 4P Lecturers

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

701-0703-00L Environmental Ethics (University of Zurich)

W 3 credits 2V University lecturers

Abstract
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

851-0745-00L Ethics Workshop: The Impact of Digital Life on Society

W 2 credits 2S E. Vayena, A. Blasimme, J. Sleigh, to be announced

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Objective
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

This course is interdisciplinary. If your department offers this course, please register there if possible.

The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored.

Throughout the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

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### Content

#### Ethics of Life Sciences and Biotechnology

**Abstract**

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

**Objective**

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

- **A.** Identify ethical issues in in life sciences and biotechnology.
- **B.** Analyze and critically discuss ethical issues in life sciences and biotechnology.
- **C.** Become aware of relevant legal and public policy frameworks.
- **D.** Distinguish different ethical approaches and argumentative strategies in applied ethics.
- **E.** Recognize how ethical issues relate to different accounts of technology and innovation.
- **F.** Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
- **G.** Autonomous anticipate ethical issues.
- **H.** Propose and communicate solutions to ethical challenges and dilemmas.

**Content**

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

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### Ethics and Scientific Integrity for Doctoral Students

**Abstract**

This course is interdisciplinary. If your department offers this course, please register there if possible.

**Objective**

Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.
Part I on Moodle

The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II

The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice

For doctoral students only.

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II).

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Decision-making</td>
<td>Critical Thinking</td>
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Integration into Scientific Community

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Abstract

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective

Participation in summer or winter schools with a maximum duration of 3 days.

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Abstract

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Objective

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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**Doctorate Biology - Key for Type**

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**Key for Hours**

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<td>colloquium</td>
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<td>P</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
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<td>R</td>
<td>revision course / private study</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Subject Specialisation

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<td>M. Fussenegger</td>
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<td>This seminar features the latest progress in molecular biotechnology, including topics from bioengineering, synthetic biology as well as gene- and cell-based therapies.</td>
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<td>636-0009-00L</td>
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<td>Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.</td>
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<td>The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.</td>
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<tr>
<td>Content</td>
<td>Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0104-00L</td>
<td>Biophysical Methods</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. J. Müller</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.</td>
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<tr>
<td>Objective</td>
<td>Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as research in biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.</td>
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<tr>
<td>Content</td>
<td>The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude. The biophysical methods to be taught will include:</td>
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<tr>
<td></td>
<td>• Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy</td>
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<td></td>
<td>• Super resolution optical microscopy: STED, PALM, STORM, other variations</td>
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<td>• Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain</td>
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<td></td>
<td>• X-ray, electron and neutron diffraction</td>
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<td></td>
<td>• MRI imaging</td>
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<td></td>
<td>• Scanning tunneling microscopy and atomic force microscopy</td>
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<tr>
<td></td>
<td>• Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry</td>
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<td></td>
<td>• Surface plasmon resonance-based biosensors</td>
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<td></td>
<td>• Molecular pore-based sensors and sequencing devices</td>
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<td></td>
<td>• Mechanical molecular and cellular assembly devices</td>
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<td></td>
<td>• Optical and magnetic tweezers</td>
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<td></td>
<td>• CD spectroscopy</td>
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<td></td>
<td>• Optogenetics</td>
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<td></td>
<td>• Molecular dynamics simulations</td>
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</tbody>
</table>

### Literature

Methods in Molecular Biophysics (5th edition), Sershen et al., Cambridge University Press
Objective

Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e., the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

Content

1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

Lecture notes

All lecture material will be made available online via Moodle.

Literature

The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:

- Murray, Mathematical Biology, Springer
- Forgacs and Newman, Biological Physics of the Developing Embryo, CUP
- Keener and Sneyd, Mathematical Physiology, Springer
- Fall et al., Computational Cell Biology, Springer
- Szallasi et al., System Modeling in Cellular Biology, MIT Press
- Wolkenhauer, Systems Biology
- Kreyszig, Engineering Mathematics, Wiley

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

636-0117-00L Mathematical Modelling for Bioengineering and Systems Biology

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Assessed</th>
<th>Fostered</th>
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</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
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</tbody>
</table>

636-0103-00L Microtechnology

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Assessed</th>
<th>Fostered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Fundamentals of semiconductors and band model</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Fundamentals of devices: transistor and diode</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Silicon processing and fabrication steps</td>
<td>assessed</td>
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<td></td>
<td>Silicon crystal structure and manufacturing</td>
<td>assessed</td>
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<td></td>
<td>Thermal oxidation</td>
<td>assessed</td>
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<td>Doping via diffusion and ion implantation</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Photolithography</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Thin film deposition: dielectrics and metals</td>
<td>assessed</td>
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<td></td>
<td>Wet etching &amp; bulk micromachining</td>
<td>assessed</td>
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<td></td>
<td>Dry etching &amp; surface micromachining</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Microtechnological processing and fabrication sequence</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Optional: Packaging</td>
<td>assessed</td>
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</tbody>
</table>

Prerequisites / notice

The information on the web can be updated until the beginning of the semester.
Biotechnology of Enzymes

**Abstract**
This course covers the role of enzymes in biotechnology, from discovery via engineering to applications in a variety of fields from food to the pharmaceutical industry.

**Objective**
Students will learn to identify opportunities for utilizing enzymes in biotechnology and develop basic and advanced enzyme engineering skills, informed by the latest research and techniques.

**Content**
This course offers an in-depth exploration of the use and engineering of enzymes in biotechnology, spanning fundamental enzymology, enzyme engineering, and applied biocatalysis. Topics will include (1) thermodynamic, kinetic, and mechanistic principles of enzyme catalysis, (2) the generation and engineering of enzymes through technologies such as protein design and directed evolution, (3) industrially applied biocatalysis, and (4) future challenges for biocatalysis.

**Lecture notes**
Notes will be provided in the form of handouts.

**Literature**
The course will use selected parts of textbooks, original scientific publications, and reviews, which will be shared during the lecture.

**Competencies**
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Communication assessed
- Personal Competencies: Self-direction and Self-management assessed

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Biological Engineering and Biotechnology

**Abstract**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objective**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content**

**Lecture notes**
Handout during the course.

**Competencies**
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Communication assessed
- Personal Competencies: Self-direction and Self-management assessed

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Biomolecular Nanotechnology

**Abstract**
Biomolecular nanotechnology is a broad field that focuses on the study and science of biological materials including DNA, RNA and proteins at length scales below 10 nm. This is a broad overview of the topic with a focus on current research themes.

**Objective**
The objective is to familiarize the students with a broad range of topics related to biotechnology, nanotechnology, and biophysics with a focus on current research and reading of scientific literature.

**Content**
Introduction to biomacromolecules; Measurement techniques for characterisation of biomacromolecules; Fundamentals of molecular recognition; Recombinant DNA; Protein engineering; Directed evolution; Protein folding; Polymers; Elastin-like polypeptides; Intelligent materials; Spatially localized hydrogels; Mechanical properties of proteins and macromolecules; Single-molecule force spectroscopy

**Literature**
Representative literature:
1. Alberts, Molecular Biology (Ch.2 Cellular chemistry).
2. Ratner, Biomaterials Science (Ch. 2.3, 2.4 Polymers & hydrogels).
3. Walsh, Protein Biochemistry, (Ch. 2. Protein Structure).

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Stem Cells: Biology and Therapeutic Manipulation

**Abstract**
Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.

**Objective**
Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.
Content
We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

Competencies
Subject-specific Competencies
- Concepts and Theories
  - Techniques and Technologies
  - Assessed

Method-specific Competencies
- Analytical Competencies
  - Media and Digital Technologies
  - Fostered

Social Competencies
- Communication
  - Fostered

Personal Competencies
- Critical Thinking
  - Fostered
- Integrity and Work Ethics
  - Fostered

636-0118-00L Introduction to Dynamical Systems with Applications to Biology

W 4 credits 3G 3G+2A M. H. Khammash

Abstract
Does not take place this semester.

Objective
Many physical systems are dynamic and are characterized by internal variables that change with time. Describing the quantitative and qualitative features of this change is the topic of dynamical systems theory. Dynamical systems arise naturally in virtually all scientific disciplines including physics, biology, chemistry and engineering. This course is a broad introduction to the topic dynamical systems.

636-0119-00L Introduction to Statistics and R

W 6 credits 3G+2A J. Kuipers

Abstract
This course offers a practical introduction to the fundamentals of data analysis and R programming including basics of data and R.

Objective
To acquire the statistical understanding to design an appropriate analysis and the practical skills to implement the analysis in R and present results.

Content
Data analysis is fundamental for arriving at scientific conclusions and testing different hypotheses. This course offers a hands-on introduction to statistical analyses including: exploratory data analysis, testing differences in populations, p-values, power calculations, multiple testing, confounding, linear regression, maximum likelihood, model selection, and logistic regression; along with the fundamentals of R programming including markdown and data handling with the tidyverse.

636-0017-00L Computational Biology

W 6 credits 3G+2A T. Vaughan, C. Magnus, T. Stadler

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e., we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e., we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phyloinformatics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g., HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSESE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Compétences

<table>
<thead>
<tr>
<th>Subject-specific Competences</th>
<th>Conceptual and Theoretical Competences</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Methods-specific Competences</td>
<td>Analytical Competences</td>
<td>Decision-making</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Personal Competences</td>
<td>Creative Thinking</td>
<td>Critical Thinking</td>
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**636-0007-00L**  
**Computational Systems Biology**  
**W** 6 credits  **3V+2U**  **J. Stelling**  
**Abstract**  
Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

**Objective**  
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

**Content**  
Biological systems biology is often observed with a limited number of entities and parameters. However, emergent properties of large biological systems can arise from the interaction of many elements. This course will therefore focus on modeling and simulation methods that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

**Lecture notes**  
http://www.csb.ethz.ch/education/lectures.html

**Literature**  


**636-0101-00L**  
**Systems Genomics**  
**W** 4 credits  **3G**  **B. Treutlein, C. Beisel, Z. He**  
**Abstract**  
This course is an introduction to the wide field of Genomics. It addresses how fundamental questions in biological systems are studied using methods in genomics and how the resulting data is analysed to make quantitative interpretations of biological phenomena.

**Objective**  
The goal of this course is to get detailed insights in how state-of-the-art DNA sequencing technologies can be applied for a qualitative and quantitative description of molecular and cellular processes and function. Students will learn how to analyse RNA-seq / transcriptomics data and make biological interpretations in a quantitative manner.

**Content**  
This course will be a mix of lecture sessions, hands-on computational data analysis using public datasets and seminars discussing own results in the context of the published studies. In the lectures we will introduce current Next-Generation Sequencing technologies and their application to address basically all facets of modern biology and biomedical research. We will cover the major sample processing methods used for investigating functional genomic aspects like transcriptome and chromatin profiling, review recent advances in (cancer) genome sequencing and give an overview of public big data sequencing projects (ENCODE, GTEX, TCGA, ...). For the computational data analysis we will focus on differential gene expression profiling (RNA-seq) experiments that have been selected from fascinating published biological studies. Data analysis based on R will follow a detailed tutorial describing all required steps of sequence read processing and will be conducted in small groups to enable every student hands-on experience.

**Lecture notes**  
The PowerPoint presentations of the lectures as well as other course material relevant for an active participation will be made available online.

**636-0554-00L**  
**Modelling and Simulation in Drug Development**  
**W** 2 credits  **3V**  **H.-M. Kaltenbach**  
**Abstract**  
This course introduces how Modelling and Simulation (=mathematical modelling) is applied today for the development of novel drugs in the pharmaceutical industry. Background lectures are combined with hands-on exercises on real-world examples.

**Objective**  
The goal of this course is to provide students with a general understanding of drug development and pharmacology and Modelling and Simulation is used to develop new drugs. Together with the application, the course will provide the background in the statistical methodologies used to model multivariate and time-dependent data with several levels of statistical variability.

**Content**  
Understanding the pharmacology, pharmacokinetics and pharmacodynamics (PK/PD) of novel drugs is key for a successful drug development process. Modelling and Simulation of these data is at the core to gain understanding. Focusing on the application using real world examples, this course will introduce the statistical methodologies that have been developed to describe complex biological and pharmacological data with several levels of statistical variability.

**Prerequisites / notice**  
**Basics of dynamic systems (e.g., BSSE courses by Iber or Kammash, or CSB course by Stelling)**  
**Basics of statistics and R (e.g., BSSE courses by Kuipers or Kaltenbach)**
Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann

Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

263-5053-00L Technology Investing W 2 credits 3S A. Ilic, C. Jurytko

Abstract

Venture Capital is important to fund big transformational ideas and is often misunderstood by tech or research entrepreneurs. This lecture immerses participants in the role of a Venture Capitalist (VC) to learn from experienced entrepreneurs and investors. In small teams, you work on a case of a real start-up and defend the case in a simulated investment committee consisting of experienced VCs.
Objective
After attending this course, students will be able to:
- Explain the differences between VC and founder thinking
- Evaluate if a start-up is suited for venture capital ("VC readiness")
- Evaluate founder friendliness of term sheets
- Determine funding needs & strategy for a start-up from research to first round
- Write and evaluate an investment memo

Content
The course is practically oriented and features guest speakers from leading venture capital firms and start-ups. The course embraces a unique perspective combining technology and investor thinking. The seminar is structured around five days with the following themes.

The detailed program is listed here: https://bit.ly/techinvesting23

The macro picture. Why does venture capital exist? What are major tech break-through areas and their disruptive potential? We also review the differences in the US and European perspective as well as developments towards more impact and diversity conscious funds.

A peek into the mind of a VC. How to build a successful VC? Learn what key factors & processes required to build a successful venture capital company. This includes strategic decisions for investment thesis, structure of a fund, portfolio economics, valuation & ownership targets, cap table. In addition, we introduce the fundamentals of the investment process (including due diligence, term sheets, and deal memo) as well as portfolio management.

The founder’s perspective. Why should you raise venture capital and how? Learn to evaluate the founder friendliness of terms, company approach, strategic decisions, negotiation and valuation.

Fundraising types. Learn about different types of funding and their implications. This includes an overview of the Swiss ecosystem and a discussion of the different types (grants, equity, loans, SAFE, crowd, …). We also include a practical session on crypto technology for modern fund-raising using launchpads and tokenized shares.

Tying it all together. The last day is focused on simulating an investment committee meeting where the groups present their deal memos and discuss with the audience.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Probabilistic Artificial Intelligence

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMPDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication

Personal Competencies
- Cooperation and Teamwork
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Advanced Bioengineering

Only for Biotechnologie Master, Programme Regulations 2021 or doctoral students of D-BSSE.

Prerequisites / notice
The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.
This course provides an overview of modern concepts of bioengineering across different levels of complexity, from single molecules to systems, microscaled reactors to production environments, and across different fields of applications.

### Objective
Students will be able to recognize major developments in bioengineering across different organisms and levels of complexity and be able to relate it to major technological and conceptual advances in the underlying sciences.

### Content
Molecular and cellular engineering; Synthetic biology; Engineering strategies in biology; from single molecules to systems; downscaling bioengineering; Bioengineering in chemistry, pharmaceutical sciences, and diagnostics, personalized medicine.

### Lecture notes
Handouts during class

### Literature
Will be announced during the course

<table>
<thead>
<tr>
<th>Competencies</th>
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<th>Hours</th>
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### Transferable Skills

#### Transferable Skills Course I (1-3 days)
- **Title**: Scientific Writing Seminar for PhD Students
- **Type**: W
- **ECTS**: 2
- **Hours**: 2G
- **Lecturers**: C. Hamilton

This course helps young scientists become better writers. This course focuses on writing well-organized and clear journal articles that students may submit for publication afterwards in order to advance their careers.

**Abstract**
In this course, students will learn how to write an effective journal article for their specific field. Students will learn more about writing all the sections of an IMRAD article (Introduction, Methods and materials, Results, and Discussion). Then students will closely study several key principles for writing clearly in English. Various aspects of the publication process will also be discussed. By the end, students will know what to do and how to do it when writing a clear and effective journal article.

**Lecture notes**
The course includes short lectures, open discussions, exercises with classmates, and peer review in small groups. The lecturer will give feedback on completed assignments. This is a friendly, hands-on course so students can really get the most out of it.

**Literature**
A script with reading material and exercises will be provided by the lecturer. For the lessons on style, students should have the following book:

- Writing Science in Plain English by Anne E. Greene
- ISBN: 9780226026374
- Published May 2013 by the University of Chicago Press

**Prerequisites / notice**
Students should be ready to write about their own research. This will require having some results to write about, even if they are preliminary. Students should also bring a laptop computer to each class for the various writing activities we do.

**Competencies**
- Method-specific Competencies
- Project Management
- Communication
- Creative Thinking

**Number**
- 636-0023-00L

**Type**
- W

**ECTS**
- 2

**Hours**
- 2G

**Lecturers**
- C. Hamilton

---

#### Transferable Skills Course II (1-3 days)
- **Title**: Transferable Skills Course II (1-3 days)
- **Type**: W
- **ECTS**: 1
- **Hours**: 2S
- **Lecturers**: Lecturers

#### Transferable Skills Course III (1-3 days)
- **Title**: Transferable Skills Course III (1-3 days)
- **Type**: W
- **ECTS**: 1
- **Hours**: 2S
- **Lecturers**: Lecturers

---

#### Transferable Skills Course I (1-3 days, with Poster or Talk)
- **Title**: Transferable Skills Course I (1-3 days, with Poster or Talk)
- **Type**: W
- **ECTS**: 2
- **Hours**: 4S
- **Lecturers**: Lecturers

### Educational Science for Teaching Diploma and TC

### Language Courses ETH/UZH: see Science in Perspective
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Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 736 of 2667
and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

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<tr>
<td>900-0112-DRL</td>
<td>Participation in Commission I (min 1 year)</td>
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<td>900-0112-DRL</td>
<td>Participation in Commission II (min 1 year)</td>
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<td>900-0113-DRL</td>
<td>Participation in Commission II (min 1 year)</td>
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<td>851-0178-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students</td>
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<td>Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.</td>
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Content:
Part I on Moodle
The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

For doctoral students only.

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

Competencies

- Subject-specific Competencies
  - Concepts and Theories assessed
  - Decision-making assessed
  - Problem-solving assessed

- Personal Competencies
  - Critical Thinking assessed
  - Integrity and Work Ethics assessed
Abstract
This course (e-learning module followed by workshop) equips doctoral students with knowledge and tools to recognize, discuss and address ethical issues of their research.

Objective
Doctoral students learn how to identify, analyze and address ethical issues in their own research. They will also reflect on their professional role as scientists.

Content
This course introduces doctoral students to ethical issues that may occur during their research activities. After an introduction to ethics and good scientific practice, participants are familiarised with resources that can assist them with ethical decision-making (e-learning module on Moodle). In the second, face-to-face part, participants will have the opportunity to critically discuss their knowledge and share their experiences with fellow doctoral students in a discipline specific context.

Integration into Scientific Community

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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
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<td>4K</td>
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<td>4K</td>
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**Doctorate Biosystems Science and Engineering - Key for Type**

- **O**: Compulsory
- **W**+ : Eligible for credits and recommended
- **W**: Eligible for credits
- **E-**: Recommended, not eligible for credits
- **Z**: Courses outside the curriculum
- **Dr**: Suitable for doctorate

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<table>
<thead>
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<th>Key for Hours</th>
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<td>V</td>
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<td>G</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
# Subject Specialisation

## Organic Chemistry

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>529-0280-00L</td>
<td>Analytical Chemistry Seminar</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>R. Zenobi</td>
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<td></td>
<td>Analytical Chemistry Seminar</td>
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<td></td>
<td>Presentation and discussion of current research topics in analytical chemistry</td>
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<tr>
<td>529-0290-00L</td>
<td>Organic Chemistry (Seminar)</td>
<td>E-</td>
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<td>2S</td>
<td>E. M. Carreira, J. W. Bode, W. Hennemers, R. Zenobi</td>
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<td>529-0299-00L</td>
<td>Organic Chemistry</td>
<td>E-</td>
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<td>J. W. Bode, E. M. Carreira, P. Chen, K. Lang, B. Morandi, W. Hennemers, R. Zenobi</td>
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## Inorganic Chemistry

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<td>529-0169-00L</td>
<td>Instrumental Analysis</td>
<td>E-</td>
<td>0</td>
<td>2S</td>
<td>D. Günther</td>
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<td></td>
<td>Group seminar on elemental analysis and isotope ratio determinations using various plasma sources</td>
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<tr>
<td>529-0199-00L</td>
<td>Inorganic and Organometallic Chemistry</td>
<td>E-</td>
<td>0</td>
<td>2K</td>
<td>C. Copérat, M. Bezdek, D. Günther, M. Kovalenko, T. Lippert, V. Mougel, P. Steinegger</td>
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<tr>
<td>529-0455-00L</td>
<td>Laser for Micro- and Nanostructuring</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>T. Lippert, N. Shepelin</td>
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<td>Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as micro lithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.</td>
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## Literature

- FSRM, CD-ROM: An Introduction to the World of Microsystems, Neuchatel.
Abstract
This Master level course delves into the emerging field of biomolecular condensates - membrane-less organelles in cells. Using interdisciplinary concepts from biology, chemistry, biophysics, and soft matter, we will explore the biological properties of these condensates, their functions in health and disease, and their potential as new biomimetic materials for various applications.

Objective
In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similar to emulsions.

This interdisciplinary course encompasses milestone works and cutting-edge research questions in the young field of biomolecular condensates, including their properties, functions, and applications. The course begins with a lecture series that introduces the topic of condensates to an interdisciplinary audience and provides a theoretical foundation for understanding current research questions in the field. The lectures provide a base for student presentations of recent publications in the field, and for research seminars given by course lecturers, who are all active researchers with diverse expertise. Through this exciting interdisciplinary understanding of biomolecular condensates, bridging biology, chemistry, biophysics, and soft matter.

Students will not only learn how to critically read and evaluate scientific literature but will also gain valuable experience in giving scientific presentations to an interdisciplinary audience. Each presentation will require an introduction, critical analysis of the results, and a discussion of their significance, allowing student to substantiate their statements with a critical mindset that considers the pros and cons of chosen approaches and methods, as well as any limitations or possible follow-up experiments. This process will enable student to ask relevant questions and actively participate in class discussions, further enhancing their scientific skills.

In preparing the presentations, the students will have the unique opportunity to interact closely with each other and with the lecturers, who are all internationally well-established experts, and receive guidance in select a topic for the final presentation and supporting literature.

Content
The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and requires a multi-disciplinary approach that leverages and cross-fertilizes biology, physical chemistry, biophysics, and soft matter. This course will explore the properties, functions and potential applications of biomolecular condensates, including their role in neurodegenerative diseases such as Alzheimer's and Parkinson's, as well as their use as smart biomimetic materials.

This course is divided into two parts. The fist part will introduce the basic concepts essential to the study of biomolecular condensates and phase separation. Topics include: fundamental units and scales in soft matter, phase transitions in biology, biopolymers and molecular self-assembly, introduction to active matter. This will establish a foundation for the second part, which will explore milestone works and current research in the field of biomolecular condensates. Each lecture of this second part will consist of:

1) a short literature seminar, where student groups will present and discuss a milestone paper assigned in advance and
2) a research seminar, where one of the course lecturers will present their own state-of-the-art research in the field, building upon the milestone literature.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Lecture slides and some scripts will be provided.

Literature
No compulsory textbooks. Literature will be provided during the course.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Physical Chemistry

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<th>Lecturers</th>
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<td>1S</td>
<td>M. Reiher</td>
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<td>Abstract</td>
<td>Weekly seminar programme on special topics in theoretical and quantum chemistry. Talks delivered by PhD students and PostDocs as well as by external speakers.</td>
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<td>advanced course for PhD students and postdoctoral fellows</td>
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<td>Content</td>
<td>current research topics in theoretical chemistry</td>
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<td>Lecture notes</td>
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529-0460-00L | Computer Simulation | E-   | 0 credits | 1S   | P. H. Hünenberger, S. Riniker |

529-0479-00L | Theoretical Chemistry, Molecular Spectroscopy and Dynamics | W    | 1 credit | 2S   | F. Merkt, J. Richardson, R. Signorell, H. J. Wörner |

529-0489-00L | Introduction to the Construction of Measurement Devices in Physical Chemistry | W    | 2 credits | 2P   | F. Merkt |

Number
- 2 credits
- 1 credit
- 0 credits

Prerequisites / notice
- Group meeting
In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically

Institute-Seminar covering current research Topics in Physical Chemistry

Research seminar with invited lecturers

Research colloquium

Advanced High Resolution Molecular Spectroscopy

The course teaches advanced topics in molecular spectroscopy: techniques for analysing rotationally and rovibrationally resolved spectra will be discussed, the basics of FTIR spectroscopy will be reviewed, and the sources which may be used in high resolution infrared spectroscopy will be described. The fields in which high resolution infrared /THz spectroscopy is applied will also be reviewed.

The students will understand how to use the tools needed to analyze simple highly resolved spectra. They will become familiar with experimental techniques in high resolution molecular spectroscopy and will understand how molecular spectroscopy can be applied to solve problems with respect to atmospheric pollutants and the detection of molecules in interstellar space.

The students will learn how to record rotationally and rovibrationally resolved spectra in the THz and IR frequency range. For that purpose state-of-the-art sources like synchrotrons, FELs and other THz sources will be discussed. In this context, the basics of Fourier transform infrared spectroscopy will also be reviewed. The analysis of such spectra with interactive programs will then be explained. Finally, applications of high resolution molecular spectroscopy in the field of atmospheric and interstellar chemistry will be discussed. The identification and the quantitative determination of atmospheric pollutants will be discussed in detail. In addition, the identification of interstellar molecules in the context of the origin of life will be reviewed. The question of the identification of the interstellar unidentified infrared bands of the interstellar diffuse bands will also be addressed. Finally, high resolution molecular spectroscopy of chiral molecules in the context of molecular parity violation will be discussed

Calculating Free Energy Differences from Molecular Simulation: Theory and Practical Applications

Theoretical analysis as well as issues of practical implementation of state of the art free energy methods.

Recognition of the concepts that underlie the different approaches devised for the determination of free energies

A wide variety of fundamental chemical quantities such as binding or equilibrium constants, solubilities, partition coefficients, and adsorption coefficients are related to the difference in free energy between particular (non)physical states of a system. A maze of computational techniques to calculate free energies is nowadays available that differ in efficiency and accuracy. However, most of them are rooted in a few basic ideas. In the lecture state of the art methods are discussed in light of these basic ideas.

Handouts will be provided

Theoretical Chemistry Seminar

Seminar on recent developments in Theoretical Chemistry presented by guest speakers.

Variert nach aktuellem Stand der Forschung

Will be announced on http://www.reiher.ethz.ch/courses-and-seminars/theoretical-chemistry.html

Cellular Matters: Properties, Functions and Applications of Biomolecular Condensates

The number of participants is limited to 30 and will only take place with a minimum of 6 participants.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

This Master level course delves into the emerging field of biomolecular condensates - membrane-less organelles in cells. Using interdisciplinary concepts from biology, chemistry, biophysics, and soft matter, we will explore the biological properties of these condensates, their functions in health and disease, and their potential as new biomimetic materials for various applications.

In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similiar to emulsions.

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Students will not only learn how to critically read and evaluate scientific literature but will also gain valuable experience in giving scientific presentations to an interdisciplinary audience. Each presentation will require an introduction, critical analysis of the results, and a discussion of their significance, allowing student to substantiate their statements with a critical mindset that considers the pros and cons of chosen approaches and methods, as well as any limitations or possible follow-up experiments. This process will enable student to ask relevant quierions and actively participate in class discussions, further enhancing their scientific skills.

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1) a short literature seminar, where student groups will present and discuss a milestone paper assigned in advance and
2) a research seminar, where one of the course lecturers will present their own state-of-the-art research in the field, building upon the milestone literature.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Lecture notes

Lecture slides and some scripts will be provided.

Literature

No compulsory textbooks. Literature will be provided during the course.

Competencies

<table>
<thead>
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<th>Subjects-specific Competencies</th>
<th>Techniques and Technologies</th>
<th>fostered</th>
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<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>fostered</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>fostered</td>
</tr>
<tr>
<td>Project Management</td>
<td>fostered</td>
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<tr>
<td>Communication</td>
<td>assessed</td>
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<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
<td>fostered</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>fostered</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<tr>
<td>Negotiation</td>
<td>assessed</td>
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<tr>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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529-0060-00L MPS Colloquium

Dr 0 credits 3K

G. Jeschke, A. Barnes, M. Ernst, P. H. Hünenberger, F. Merkt, M. Reiher, J. Richardson, R. Riek, S. Riniker, T. Schmidt

529-0690-00L ICB Seminars on Chemical and Biochemical Engineering

Dr 1 credit G. Guillén Gosálbez

Abstract

Seminar series covering current developments in Molecular Physical Science

Objective

Discussing current developments in Molecular Physical Science

Competencies

<table>
<thead>
<tr>
<th>Subjects-specific Competencies</th>
<th>Techniques and Technologies</th>
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<tr>
<td>Analytical Competencies</td>
<td>Problem-solving</td>
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Technical and Bioengineering

Number Title Type ECTS Hours Lecturers

551-0357-00L Cellular Matters: Properties, Functions and Applications of Biomolecular Condensates


At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 744 of 2667
This Master level course delves into the emerging field of biomolecular condensates - membrane-less organelles in cells. Using interdisciplinary concepts from biology, chemistry, biophysics, and soft matter, we will explore the biological properties of these condensates, their functions in health and disease, and their potential as new biomimetic materials for various applications.

In the last decade, a novel type of cell compartments called biomolecular condensates have been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similiar to emulsions.

This interdisciplinary course encompasses milestone works and cutting-edge research questions in the young field of biomolecular condensates, including their properties, functions, and applications. The course begins with a lecture series that introduces the topic of condensates to an interdisciplinary audience and provides a theoretical foundation for understanding current research questions in the field. The lectures provide a base for student presentations of recent publications in the field, and for research seminars given by course lecturers, who are all active researchers with diverse expertise. Through this exciting interdisciplinary understanding of biomolecular condensates, bridging biology, chemistry, biophysics, and soft matter.

Students will not only learn how to critically read and evaluate scientific literature but will also gain valuable experience in giving scientific presentations to an interdisciplinary audience. Each presentation will require an introduction, critical analysis of the results, and a discussion of their significance, allowing student to substantiate their statements with a critical mindset that considers the pros and cons of chosen approaches and methods, as well as any limitations or possible follow-up experiments. This process will enable student to ask relevant querions and actively participate in class discussions, further enhancing their scientific skills.

In preparing the presentations, the students will have the unique opportunity to interact closely with each other and with the lecturers, who are all internationally well-established experts, and receive guidance in selectin a topic for the final presentaton and supporting literature. At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

This course is divided into two parts. The fist part will introduce the basic concepts essentiaalto the study of biomolecular condensates and phase separation. Topics include: fundamental units and scales in soft matter, phase transitions in biology, biopolymers and molecular self-assembly, introduction to active matter. This will establish a foundation for the second part, which will explore milestone works and current research in the field of biomolecular condensates. Each lecture of this second part will consist of:

1) a short literature seminar, where student groups will present and discuss a milestone paper assigned in advance and
2) a research seminar, where one of the course lecturers will present their own state-of-the art research in the field, building upon the milestone literature.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

lecture style slides and some scripts will be provided.

No compulsory textbooks. Literature will be provided during the course

Objective
Participants learn to present scientific studies and discuss the results of their projects and selected reports from the current scientific literature.

Content
The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and requires a multi-disciplinary approach that leverages and cross-fertilizes biology, physical chemistry, biophysics, and soft matter. This course will explore the properties, functions and potential applications of biomolecular condensates, including their role in neurodegenerative diseases such as Alzheimer's and Parkinson's, as well as their use as soft biomimetic materials.

This course is divided into two parts. The fist part will introduce the basic concepts essential to the study of biomolecular condensates and phase separation. Topics include: fundamental units and scales in soft matter, phase transitions in biology, biopolymers and molecular self-assembly, introduction to active matter. This will establish a foundation for the second part, which will explore milestone works and current research in the field of biomolecular condensates. Each lecture of this second part will consist of:

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At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Lecture notes
Lecture slides and some scripts will be provided.

Literature
No compulsory textbooks. Literature will be provided during the course

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Leadership and Responsibility</td>
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Adaptability and Flexibility      fostered                      | assessed                      | assessed           |

Creative Thinking                 assessed                      | assessed                      | assessed           |

Critical Thinking                 assessed                      | assessed                      | assessed           |

Integrity and Work Ethics         fostered                      | fostered                      | assessed           |

Self-awareness and Self-reflection fostered                      | assessed                      | assessed           |

Self-direction and Self-management fostered                      | assessed                      | assessed           |

Polymer Science

Pharmaceutical Sciences

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<tr>
<th>Number</th>
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<th>Hours</th>
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<td>535-2000-00L</td>
<td>Seminar for Group Members</td>
<td>W</td>
<td>0</td>
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<td>G. Schneider</td>
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</table>

Abstract
Weekly group seminar, in which members of the research team present and discuss the results of their projects and selected reports from the current scientific literature.

Objective
Participants learn to present scientific studies and discuss the results of their projects and selected reports from the current scientific literature.

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<tr>
<td>535-0900-00L</td>
<td>Seminars on Drug Discovery and Development</td>
<td>E</td>
<td>1</td>
<td>1K</td>
<td>R. Schibli, C. Halin Winter, J. Hall, J.-C. Leroux, U. Quitterer, G. Schneider, H. U. Zeilhofer</td>
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</table>

Abstract
State-of-the-art information on drug discovery and development by experts from academia and industry.

Objective
State-of-the-art information on drug discovery and development.

Content
Seminar series of the Institute of Pharmaceutical Sciences. Experts from academia and industry report on relevant topics.

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<thead>
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Number
535-2000-00L
535-0900-00L
535-0901-00L

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 745 of 2667
Abstract
The lecture series takes place at the ETH Hönggerberg and covers a variety of major activities involved in drug discovery: selecting drug targets, technologies used in drug discovery, small, medium and large drugs, objectives of the medicinal chemist, assessing drug safety, principles of personalized medicine, designing clinical trials, how intellectual property is protected, as well as others.

Objective
The objective of the course is to gain a global understanding of most of the important phases in the discovery and development of modern synthetic and biological drugs, from the first activities to clinical trials. The lecture is intended for students that have an interest in the area and/or may consider a career working in drug discovery. This lecture course complements knowledge and experience gained in the research project performed by the PhD student.

Content
Thirteen two hour lectures for life-science PhD students and students of the Pharmaceutical Sciences Master, given by experts from the ETH, UZH, USZ and the pharmaceutical industry.

Introduction to the modern drug discovery process - Principles of drug pharmacokinetics and drug metabolism - Computer sciences in drug discovery - Drug targets - In vitro methods in drug discovery - Natural products in drug discovery - Medicinal chemistry: Chemical lead selection/optimization - Antibodies and therapeutic proteins: Targets and drugs - In vivo molecular imaging in drug discovery - Drug formulation: Key development consideration, Current new APIs challenges and FDA rising standards - Preclinical safety, adverse drug events and drug-drug interactions - Clinical development steps including trial design - Intellectual property in drug discovery and development

Lecture notes
The lecture series takes place at the ETH Hönggerberg and covers a variety of major activities involved in drug discovery: selecting drug targets, technologies used in drug discovery, small, medium and large drugs, objectives of the medicinal chemist, assessing drug safety, principles of personalized medicine, designing clinical trials, how intellectual property is protected, as well as others.

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Literature
To be distributed during the lecture

Prerequisites / notice
Formally none, but a basic understanding in biochemistry, physiology and chemistry is highly desirable as it will certainly help to get the most from the lectures.

Additional Courses

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<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>529-0195-00L</td>
<td><strong>Scientific Information Retrieval &amp; Management in Life Sciences and Chemistry</strong></td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>O. Renn, L. Betschart, J. Dolenc</td>
</tr>
</tbody>
</table>

Abstract
Students learn how to effectively retrieve, critically judge, analyze, and manage published scientific information – important skill sets in chemistry and life sciences where scientists need to deal with vast amounts of information. The course, using practical examples, also covers scientific writing, visualizations, science communication and state-of-the-art technologies such as text mining.

Objective
Students are made aware about the wide variety of information solutions that exist today for all kinds of research processes, get an independent understanding of how they are derived and learn how to critically judge their quality. They learn how scientific communication works today and on which concepts and principles it is based. They develop the ability to select appropriate, subject-specific databases or tools for a given specific scientific question based on a sound understanding on how a tool or database has been developed and maintained, thus building the personal capacity of doing research effectively and efficiently by integrating scientific information into the research process when needed. Students learn how to evaluate information solutions, to build suitable search strategies and to integrate them in their information workflows. Also, they learn how to effectively communicate their own scientific results using various distribution channels and to measure the impact of their outreach activities. Overall, they gain the ability to perform all steps of the research cycle in a time- and cost-efficient manner, from the research strategy up to writing a first paper and their PhD. thesis.

Content
The course has been primarily designed for Ph.D. students, also for the Life Science Zurich Graduate School, but is also open to Master students. In a series of 12 units, which always include practical examples (for some lectures a notebook is required), the use of scientific information is taught not in a database-centric view but corresponding to the steps through which scientific research is conducted – including the dissemination of scientific results. This is particularly interesting for students who are about to write-up their first paper or thesis.

Students will learn about the different types of information resources and tools, get an insight into the numerous databases and tools that exists and how those are built and maintained, enabling them to critically judge the value and trustworthiness of an information resource. Additionally, they will learn how to communicate their own scientific results properly, using also additional measures that are reflected by alternative metrics.

The following topics are covered in twelve modules:
1. & 2. The world of scientific publishing: basics, publishing models
3. Searching and retrieving scientific information using search engines and literature databases
4. Searching and retrieving scientific information using subject-specific databases in chemistry and materials science
5. Searching and retrieving scientific information using subject-specific databases in life sciences
6. Tools for analyzing scientific information
7. Tools for managing scientific information and sharing knowledge, including pipelining tools
8. Patents
9. Text (literature) mining
10. Visualizing molecules for lab reports, presentations, posters, and publications
11. Scientific writing, good design & good scientific practice
12. Communicating & analyzing the impact of (your) science

Lecture notes
The slide deck and supplementary materials will be made available in the teaching document repository (ILIAS) after each lecture.

Competencies
- Method-specific Competencies
  - Analytical Competencies
  - Media and Digital Technologies
  - Project Management
  - Communication
  - Critical Thinking

- Social Competencies
  - fostered

- Personal Competencies
  - fostered

Transferable Skills

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>900-0100-DRL</td>
<td><strong>Transferable Skills Course I (1-3 days)</strong></td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>Lecturers</td>
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</table>

Abstract
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

<table>
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<th>Number</th>
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<td><strong>Transferable Skills Course II (1-3 days)</strong></td>
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<td>Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.</td>
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<tr>
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<th>Seminars</th>
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Transferable Skills Course I (1 week, with Poster or Talk)  
Only for doctoral students.

Abstract: Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective: Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Transferable Skills Course II (1 week, with Poster or Talk)  
Only for doctoral students.

Abstract: Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

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Objective: Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Participation in Commission I (min 1 year)  
Only for doctoral students.

Abstract: Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective: Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Participation in Commission II (min 1 year)  
Only for doctoral students.

Abstract: Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective: Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Member of Executive Board (min 1 year)  
Only for doctoral students.

Abstract: Active participation in the presidium or executive board of a university group for at least 1 year.

Objective: Active participation in the presidium or executive board of a university group for at least 1 year.

Ethics and Scientific Integrity for Doctoral Students in Chemistry and Related Fields  
C. Copéret, S. J. Sturla

Abstract: This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a context specific to research in chemistry.

Objective: Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.
Part I on Moodle

The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)
Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e., regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice)
Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained
Module 4: Setting up a Strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).
Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e., how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II

The second, face-to-face part of this course focuses on chemistry-specific aspects. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Lecture notes

Integration into Scientific Community

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<thead>
<tr>
<th>Number</th>
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Data: 02.07.2024 12:39 Autumn Semester 2024 Page 749 of 2667
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### Abstract
Participation in summer or winter schools with a minimum duration of 1 week.

### Objective
Participation in summer or winter schools with a minimum duration of 1 week.

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**Autumn Semester 2024**
Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

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<td></td>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td></td>
<td>A</td>
<td>independent project</td>
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<td></td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Informal seminars with both internal and external speakers on current topics in Structural Geology, Tectonics and Rock Physics. The seminar series provides an opportunity to convey the latest research results to students and staff.

Seminar I: Heat and Mass Transfers in Magmatology

- Abstract: Heat and mass transfers from the mantle to the crust control many aspects of the differentiation of our planet, including (1) primitive melt chemistry, (2) layering of the crust, (3) type of volcanic eruption, (4) formation of mineral deposits. This year, we will focus on processes in crystal mushes (formation, crystallization, remobilization, degassing).
- Objective: This class will allow the students to learn about the modern methods and ideas on heat and mass transfers in magmatology through classic and recently published papers.
- Content: The class will focus mostly on 1) reading literature on topics of interests, 2) oral and written presentations of the papers, 3) exercises illustrating the topic, to allow students to work by themselves on some well-defined problems.

Research Seminar Structural Geology and Tectonics

- Abstract: A seminar series with invited speakers from both inside and outside the ETH.
- Objective: The seminar series provides an opportunity to convey the latest research results to students and staff.
- Content: Informal seminars with both internal and external speakers on current topics in Structural Geology, Tectonics and Rock Physics. The current program is available at: http://www.structuralgeology.ethz.ch/news-and-events/events-and-seminars.html

Transferable Skills

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<th>Number</th>
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Objective
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 753 of 2667
and prove your participation with the appropriate certificate.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL Participation in Commission I (min 1 year)
Only for doctoral students.

W 1 credit 2P Lecturers

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year)
Only for doctoral students.

W 1 credit 2P Lecturers

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year)
Only for doctoral students.

W 2 credits 4P Lecturers

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

651-6001-00L Ethics and Scientific Integrity for Doctoral Students of D-EAPS

W+ 1 credit 2S T. I. Eglinton, H. Stoll

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a discipline specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

Content
Part I
The self-paced e-learning course consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For Doctoral Students of D-ERDW only

Competencies

| Subject-specific Competencies | Concepts and Theories | assessed |
| Method-specific Competencies | Decision-making | assessed |
|                              | Problem-solving | assessed |
| Personal Competencies | Critical Thinking | assessed |
|                          | Integrity and Work Ethics | assessed |

Integration into Scientific Community

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Abstract
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0160-DRL Summer School II (1 week, with Poster or Talk) W 3 credits 6K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0161-DRL Summer School III (1 week, with Poster or Talk) W 3 credits 6K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0162-DRL External Conference I (incl. Poster or Talk) W 1 credit 2K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0163-DRL External Conference II (incl. Poster or Talk) W 1 credit 2K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
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900-0164-DRL External Conference III (incl. Poster or Talk) W 1 credit 2K Lecturers
Only for doctoral students.
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Objective
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Doctorate Earth Sciences - Key for Type

| W+ | Eligible for credits and recommended |
| W  | Eligible for credits                |
| E- | Recommended, not eligible for credits |
| Z  | Courses outside the curriculum     |
| Dr | Suitable for doctorate             |
| O  | Compulsory                         |

Key for Hours

| V  | lecture                        |
| G  | lecture with exercise          |
| U  | exercise                       |
| S  | seminar                       |
| K  | colloquium                     |
| P  | practical/laboratory course    |
| A  | independent project           |
| D  | diploma thesis                 |
| R  | revision course / private study|

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Workshop & Lecture Series on the Law & Economics

**CIS PhD Colloquium**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 615G932C

Mind the enrolment deadlines at UZH:

**Objective**

The aim of this colloquium is that the presenters receive feedback on their research at an important stage (a stage at which significant changes of direction, methodology, etc. may still be undertaken) in the PhD process.

**Lecture notes**

Distributed electronically.

**Prerequisites / notice**

Dates: See http://www.cis.ethz.ch/education/index

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**Startups and Law**

Particularly suitable for students of D-ITET, D-MAVT.

**Objective**

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

**Lecture notes**

A comprehensive script will be made available online on the moodle platform.

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**Workshop & Lecture Series on the Law & Economics**

Particularly suitable for students of D-BAUG, D-BIOL, D-BSSE, D-CHAB, D-ITET, D-MAVT.

**Abstract**

Papers discussed in the workshop and lecture series are posted in advance on the course web page.

**Objective**

The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods applied to intellectual property, innovation, antitrust, privacy and technology policy issues. In particular, theoretical models, empirical and experimental research as well as legal research methods will be represented.

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**The Role of Intellectual Property in the Engineering and Technical Sector**

Particularly suitable for students of D-BAUG, D-BIOL, D-BSSE, D-CHAB, D-ITET, D-MAVT.

**Abstract**

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.
Objective
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice
The lecture addresses students in the fields of engineering, science and other related technical fields.

Competencies
Subject-specific Competencies | Concepts and Theories | assessed
Method-specific Competencies | Problem-solving | assessed
Personal Competencies | Critical Thinking | assessed
| Self-awareness and Self-reflection | assessed

851-0252-04L Behavioral Studies Colloquium

Abstract
This colloquium offers an opportunity to discuss recent and ongoing research and scientific ideas in the behavioral sciences, both at the micro- and macro-levels of cognitive, behavioral and social science.

The colloquium features invited presentations from internal and external researchers as well as presentations of doctoral students close to submitting their dissertation research plan.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice
The lecture addresses students in the fields of engineering, science and other related technical fields.

Competencies
Subject-specific Competencies | Concepts and Theories | fostered
Method-specific Competencies | Techniques and Technologies | fostered
Analytical Competencies | Project Management | fostered
Social Competencies | Communication | fostered
Personal Competencies | Adaptability and Flexibility | fostered
| Creative Thinking | fostered
| Critical Thinking | fostered
| Integrity and Work Ethics | fostered
| Self-awareness and Self-reflection | fostered
| Self-direction and Self-management | fostered

851-0252-01L Human-Computer Interaction: Cognition and Usability
W 3 credits 2S C. Hölscher, I. Barisic, B. Davison

Particularly suitable for students of D-ARCH, D-INFK, D-ITET.

Abstract
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability, with a focus on applying them to real situations.

Objective
Presentations will cover the basics of human-computer interaction and selected topics:
- History of HCI
- Research ethics
- Literature reviews
- Participants-free methods: cognitive walkthrough and heuristic evaluation
- Card sorting and information architecture
- Usability studies
- Unmoderated research and diary studies
- Surveys
- User Logs and metric frameworks

On a weekly basis, students will conduct authentic research in class covering the topics above. They will submit their in-class research results regularly and also present their findings to the class once per semester.

The final project demonstrates class topic adoption by deeply exploring one HCI problem using the covered methods and tools. Students will choose a research topic and execute their research plan. They will individually write a formal report including problem definition, literature review, methodology, findings and discussion.

851-0252-05L Research Seminar Cognitive Science
W 2 credits 2S C. Hölscher, S. Andraszewicz

Prerequisite: Participants should be involved in research in the cognitive science group.

Abstract
The colloquium provides a forum for researchers and graduate students in cognitive science to present/discuss their ongoing projects as well as jointly discuss current publications in cognitive science and related fields. A subset of the sessions will include invited external visitors presenting their research. Participants of this colloquium are expected to be involved in active research group.
Objective
Graduate students train and improve their presentation skills based on their own project ideas, all participants stay informed on current trends in the field and have the opportunity for networking with invited scholars.

851-0585-41L Computational Social Science

| W | D. Helbing, C. I. Hausladen, J. C.-Y. Yang |

Abstract
The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g., sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work.

Objective
Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

Computational Social Science and Global Systems Science serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e. an interdisciplinary integration of knowledge.

Literature
Ball: Why Society Is A Complex Matter
- Helbing: Social Self-Organization
- Helbing: Managing Complexity
- Colander/Kupers: Complexity and the Art of Public Policy
- Mitchell: Complexity
- Buckley: Society – A Complex Adaptive System
- Castelli/Haferty: Sociology and Complexity Science
- Mikhailov/Calenbuhr: From Cells to Society
- Mainzer: Thinking in Complexity
- Sawyer: Social Emergence
- Books published by the Santa Fe Institute

Computational Social Science
https://science.sciencemag.org/content/sci/323/5915/721.full.pdf

Manifesto of Computational Social Science
https://link.springer.com/article/10.1140/epjst/e2012-01697-8

Social Self-Organisation

How simple rules determine pedestrian behaviour and crowd disasters
https://www.pnas.org/content/108/17/6884.short

Peer review and competition in the Art Exhibition Game
https://www.pnas.org/content/113/30/8414.short

Generalized network dismantling
https://www.pnas.org/content/116/14/6554.short

Computational Social Science: Obstacles and Opportunities
https://science.sciencemag.org/content/369/6507/1060?rss=1

Bit by Bit: Social Research in the Digital Age
https://www.amazon.co.uk/Bit-Social-Research-Digital-Age-ebook/dp/B072MPFX2/

Further literature will be recommended in the lectures.

Prerequisites / notice
Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving fostered
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

851-0609-06L Governing the Energy Transition

| W | 2 credits | T. Schmidt, L. P. Fesenfeld |

Primarily suited for Master and PhD level.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 759 of 2667
This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-economic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.

Objective
- To gain an overview of the history of the transition of large technical systems
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions
- To gain knowledge on the role of policy and politics in energy transitions

Content
Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary. This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The grade will be determined by a final exam.

Lecture notes
Slides and reading material will be made available via moodle.ethz.ch (only for registered students).

Prerequisites / notice
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

851-0252-10L Project in Behavioural Finance W 3 credits 2S S. Andrászewicz, C. Hölscher

Abstract
In this seminar, students will study cognitive processes, behaviour and the underlying biological response to financial decisions. Research methods such as asset market experiments, lottery games, risk preference assessment, psychometrics, neuroimaging and psychophysiology of decision processes will be discussed. Financial bubbles and crashes will be the core interest.

Objective
This course has four main goals:
1) To learn about the most important topics within Behavioural Finance
2) To learn to effectively select, review and present information using modern telecommunication tools
3) To practice working on group projects in hybrid working conditions (online + in-person)
4) To solve an applied behavioral finance business case stemming from an industry partner

Content
The course does not contain mandatory reading. Instead, it offers suggested literature that provides guidance to the students who, prepare 2 credits

This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and assesses how to integrate knowledge from different disciplines, how to engage with societal actors, or how to secure broader impact of research. They learn to critically reflect their own research project in its societal context and on their role as scientists.

The seminar covers the following topics:
(1) Theories and concepts of inter- and transdisciplinary research
(2) The specific challenges of inter- and transdisciplinary research
(3) Collaborating between different disciplines
(4) Engaging with stakeholders
(5) 10 steps to make participants’ research projects more societally relevant

Throughout the course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.
Literature

The following open access article builds a core element of the course:
available at (open access): http://www.ingentaconnect.com/contentone/oekom/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used:
https://naturalsciences.ch/topics/co-producing_knowledge
https://www.shapeidtoolkit.eu

Prerequisites / notice
Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00)

Competencies

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Abstract

Social Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks, including statistical and mathematical methods. In this course, the emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective

The following topics will be covered:

- Introduction to network models and their applications
- Stylized models:
  * uniform random graph models
  * small world models
  * preferential attachment models
- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)
- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Content

The following topics will be covered:

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- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)
  * Models for relational event data: dynamic network actor models (DyNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Literature


Prerequisites / notice

Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.
Adaptability and Flexibility fostered 2V, A. Tacconelli

Concepts and Theories fostered

Contract Design I is taught by Professor Stremitzer and aims to bridge the gap between economic contract theory, contract law, and the assessed


Communication fostered

Handouts, prerecorded videos, slides, case studies, and other materials available on a dedicated webpage: contractdesign.org. Access to this webpage is free of charge for ETH students as ETH purchased a license for ETH students.

UZH and UNISG students should check out the description of the class at their respective home institutions.

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH students also have to complete an additional group project.

1) You will take weekly computer-based quizzes during class time. Thus, it is important that you attend the lectures to be able to finish the quizzes and pass this course.
2) You compose short responses to take-home questions on case studies we assign and upload them ahead of class (Pass/Fail).

The course follows a flipped-classroom model: You will watch learning videos specifically produced for this course ahead of class. We will use class time to discuss real-world case studies. The videos will be made available before the lecture each week and need to be watched ahead of coming to class. Computer-graded quizzes at the beginning of each class will test students’ understanding of the concepts introduced in the videos.

As the emphasis of this class is on class discussion, attendance is mandatory. Absent important reasons, you cannot miss class more than twice.

The lectures will be recorded but only made available to those who miss lectures with excused absence.

For ETH students: Your grade will consist of two parts:

1) You will take weekly computer-based quizzes during class time. Thus, it is important that you attend the lectures to be able to finish the quizzes and pass this course.
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UZH and UNISG students should check out the description of the class at their respective home institutions.

Lecture notes

Handouts, prerecorded videos, slides, case studies, and other materials available on a dedicated webpage: contractdesign.org. Access to this webpage is free of charge for ETH students as ETH purchased a license for ETH students.
Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT.

If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

### Course Outline

#### Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving

#### Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Negotiation

#### Personal Competencies

- Creative Thinking

### Law & Tech

**W** 3 credits  **2S**

**A. Stremitzer, J. Merane**

**Abstract**

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

In previous years, the course has featured esteemed speakers from various sectors, including industry leaders like Google, NGOs such as Digital Society Switzerland and The European Consumer Organization, regulatory bodies like the Swiss Competition Commission, and noted academics.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

**Objective**

The planned course outline is below.

- Overview of Law and Technology
- Fundamental Rights
- AI & Discrimination
- Landmark Big Tech Cases
- Regulation of Digital Platforms & Content Moderation
- Online Consumer Protection
- Law and Tech Scholarship Series

A number of recent regulations will be discussed, including the EU's AI Act, the Digital Services Act (DSA), and the Digital Markets Act (DMA), as well as emerging internet phenomena, like ChatGPT.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Law & Tech (851-0732-06L, HS 2024)" and enroll.

**Prerequisites / notice**

You need some background knowledge in probability and statistics. You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Law & Tech (851-0732-06L, HS 2024)" and enroll.

**Competencies**

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Media and Digital Technologies
- Communication

Method-specific Competencies

- Decision-making
- Problem-solving
- Customer Orientation
- Negotiation

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Negotiation

Personal Competencies

- Creative Thinking
- Critical Thinking

### Complex Social Systems: Modeling Agents, Learning, and Games

**Prerequisites:** Basic programming skills, elementary probability and statistics.

**Abstract**

This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and to communicate their results through a project report and a short oral presentation.

**Objective**

See your own field of study in a wider context ("Science in Perspective"), e.g. see the psychological, social, economic, environmental, historical, ethical, or philosophical connections and implications. Learn to think critically and out of the box. Question what you believe you know for sure. Get to know surprising, counterintuitive properties of complex (non-linearly interacting, networked, multi-component) systems. Learn about collaboration.

**Content**

By the end of the course, the students should be able to better understand the literature on complex social systems, develop their own models for studying specific phenomena and report results according to the standards of the relevant scientific literature by presenting their results both numerically and graphically.

At the end of the course, the students will deliver a report, computer code and a short oral presentation. To collect credit points, students will have to actively contribute and give a circa 30 minutes presentation in the course on a subject agreed with the lecturers, after which the presentation will be discussed. The presentation will be graded.

Students are expected to implement themselves models of techno-socio-economic processes and systems, particularly agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature, its presentation, and documentation by a project report.

**Lecture notes**

The lecture slides will be presented on the course Moodle after each lecture.
851-0252-08L  Evidence-Based Design: Methods and Tools for Evaluating Architectural Design  W  3 credits  2S  M. Gath Morad, C. Hölscher, L. Narvaez Zertuche, C. Veddeler

Abstract
Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

Objective
The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

851-0586-03L  Applied Network Science: Sports Networks  W  3 credits  2S  U. Brandes

Abstract
We study applications of network science methods, this semester in the domain of sports. Topics are selected for diversity in sports, research questions, and techniques with applications such as passing networks, team rankings, or career trajectories.

Student teams present results from the recent literature, possibly with replication, in a conference format.

Objective
Network science as a paradigm is entering domains from engineering to the humanities but application is tricky. By examples from recent research on sports analytics, students learn to appreciate that, and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.

Prerequisites / notice
The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

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Student teams present results from the recent literature, possibly with replication, in a conference format.

Objective
Network science as a paradigm is entering domains from engineering to the humanities but application is tricky. By examples from recent research on sports analytics, students learn to appreciate that, and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge assessed

The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a

Doctoral candidates from all ETH departments, whose research is related to global sustainable development issues, and conducting

Communication

Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand,

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a

- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.

Content

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Technics and Technologies

Method-specific Competencies
- Analytical Competencies
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

Ethics Workshop: The Impact of Digital Life on Society

Open to all Master level / PhD students.

Abstract

This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Objective

- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.

Content

The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

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Competencies

Subject-specific Competencies
- Concepts and Theories
- Technics and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

Building a Robot Judge: Data Science for Decision-Making

Does not take place this semester.

Abstract

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content

Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

ETH4D PhD Seminar: Research for Global Development

Doctoral candidates from all ETH departments, whose research is related to global sustainable development issues, and conducting research in low- or middle-income countries are invited to give a presentation about their on-going work and discuss their doctoral project with a diverse group of researchers.

Objective

Doctoral students are able to present their doctoral project to an interdisciplinary audience and to respond to questions within a wider global sustainable development context.

Introduction to Methods in Learning Sciences I

Course registration targeted primarily at students enrolled in the ETH-EFPL joint doctoral program in the Learning...
The course aims at providing students with practical knowledge and skill of processing, interpreting and analyzing empirical educational data, including different lenses through which to view the nature of inquiry in the field, research design, and an overview of quantitative, qualitative and mixed methods research.

The course will be centered around exploring methodological perspectives by focusing on conceptual aspects of datasets and experiments in the Learning Sciences. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, creating and justifying research designs, performing data analysis).

The course has the following components: a) Planning design-based research/research designs, b) Overview of quantitative, qualitative, mixed methods in Learning Sciences, c) Ethics of Learning Sciences research.

Comprehensives fostered theoretic and social competencies in the research plan. The course makes students experience an exemplary human-centered design process. They will learn about and practically apply human-centered design and evaluation methods that will allow them to view their solution from the human perspective, e.g., the user, developer or website owner perspective. By taking part in the evaluation of other teams, they will also take the user perspective themselves.

The course is particularly suitable for all students who have already completed the course “Human-centered IT Security and Privacy” as some of the concepts introduced will practically be applied in this course. However, the relevant literature and necessary material will be provided to all students and basic concepts will be briefly summarized so that all interested students can participate.

After an introduction on usable security as the intersection of computer science and psychology, students will form teams and work on exemplary security- or privacy-related research questions. The teams will develop and evaluate a concept for a human-centered solution.

The course makes students experience an exemplary human-centered design process. They will learn about and practically apply human-centered design and evaluation methods that will allow them to view their solution from the human perspective, e.g., the user, developer or website owner perspective. By taking part in the evaluation of other teams, they will also take the user perspective themselves.
At the beginning of the course, the students will receive an introduction to usable IT security and privacy and relevant concepts. Afterwards, a selection of current research questions from that area will be presented. The students form teams and select one of the proposed research questions. This question will accompany the students throughout the semester. They will design and evaluate a concept for a human-centered solution to that question. To be able to do so, they will receive input on human-centered design and evaluation tools. Their progress and the inclusion of the human perspective will be subject to feedback in milestone presentations. The students’ human-centered solution can take the form of a concept (e.g., a concept for a product or app), interface (e.g., a visual or tangible interface), or prototype (e.g., sketches, a click-dummy or a built prototype). The solution will then be subject to evaluations. The solutions will be user-tested by members of other teams that thereby take the perspective of a user themselves. In addition, the solutions will be analyzed from different stakeholders’ perspectives, such as developers or website owners. Finally, the students will reflect on potential changes that results from the evaluations and their consequences.

Literature


Prerequisites / notice

This course is especially recommended after the related lecture "851-0390-00 G Human-Centered IT Security and Privacy". However, previous participation in the lecture is not a requirement and not necessary for succeeding in the course.

Competencies

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork assessed
Customer Orientation fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered
Psychedelic science is a multidisciplinary field of study that involves scholars of the mind and scholars of the natural sciences. In this course, psychedelic science is presented mainly from the point of view of psychology, but will additionally also be considered from the viewpoints of pharmacology, physiology, psychotherapy, philosophy, religion, and politics. All contributions will also be reflected on from the viewpoint of the humanities and psychology. The psychedelic studies treated in this course that involve humans focus on controlled and ethically approved studies where these substances are administered to medically screened, prepared, and supported participants.

Private/illlicit use of psychedelics is not a topic of this course.

A psychedelic experience can be characterized as a temporary nonordinary state of consciousness (NSC) that is occasioned by classic (serotonergic) psychedelics such as psilocybin, mescaline, N,N-dimethyltryptamine (DMT), and lysergic acid diethylamide (LSD). Psychologically, the psychedelic experience can mainly manifest at the perceptual, cognitive, affective, volitional, and somesthetic level. The nonordinary perceptual spectrum ranges from visions (e.g., patterns or beings) to the subjective experience of an all-encompassing oneness, which also transcends the distinction between the perceiver and the perceived. The nonordinary cognitive spectrum ranges from no longer functional thinking to very clear thinking, the nonordinary affective spectrum, for example, from deepest sadness to highest bliss, the nonordinary volitional spectrum from the feeling of being able to somewhat influence what is happening to the feeling of having no longer a will of one’s own, and the nonordinary somesthetic spectrum, for example, from feelings of bodily heaviness to compression to feelings of bodily lightnessfloating.

Heuristically, as one possibility, a psychological typology of the psychedelic experience can be characterized to fall into three main types of religious-like experiences (which may be interpreted religiously/spiritually by the individuals having them, but may also be interpreted materialistically or agnostically), autobiographical experiences, and tripartite-mind (cognitionaffectconation) miscellaneous experiences. Investigating the psychedelic experience is a worthwhile endeavor as, for instance, certain aspects of this experience have been associated with increased subjective well-being both for healthy individuals as well as for patients – for example, persistent positive effects on attitudes, mood, and behavior in healthy individuals and sustained symptom reduction in individuals suffering from depression, anxiety, and addiction.

Psychedelic science is overall a large multidisciplinary effort that requires collaboration of scholars of the mind and scholars of the natural sciences to advance the scientific knowledge of it. In this spirit, this course will – besides the main lecturer (PD Dr. phil. Kurt Stocker, a psychologist) – also involve further psychedelic-scientific scholars giving individual lectures in their respective field of expertise psychology (PD Dr. phil. Katrin Preller, University of Zurich & Yale University); pharmacology (Dr. phil. nat. Dino Luethi, University Hospital Basel; Dr. phil. nat. Deborah Rudin, University Hospital Basel; Prof. Dr. phil. Linda Simmler, University of Basel), physiology (PD Dr. sc. nat. Felix Scholkmann, University of Zurich & University of Bern), psychiatry/psychotherapy (Prof. Dr. med. Gregor Hasler, University of Fribourg; Dr. med. Dr. sc. ETH Milan Scheidegger, University of Zurich), and philosophy (Dr. Peter Sjöstedt-Hughes, University of Exeter). Overall, this course will provide an informative overview of the research foundations that have made psychedelic science what it is today, and will also provide an identification of the research frontiers that must be addressed to expand the psychedelic science of tomorrow.
851-0019-00L  Insect Histories: Bugs that Made the Modern World  W  3 credits  2S  T. Bartoletti

Abstract
The seminar explores insects as historical actors and their diverse interactions with human societies over time and space. It offers an overview of recent approaches in environmental history and multispecies ethnography while providing an analytical framework to understand global processes of natural resource exploitation, knowledge formation, and imperialism.

Objective
The objective is to analyze human-insect interactions by identifying key historical factors (economic, scientific, political). Students will integrate current frameworks in the study of environmental history through the combination of primary sources and interdisciplinary research. They will develop skills rooted in their interest in insects and learn to translate them into feedback to peers.

Content
Scholars typically approach Nature-related histories by focusing on environmental change, the commodification of resources, and the legacy of natural history collections. Examples of this approach include studies on deforestation, dam constructions, the rubber boom, and the colonial history of European museums. In contrast to these commonly explored topics, insects are often underrepresented in historical research, both as living creatures and metaphors. Addressing this gap, the seminar explores human-insect interactions from a global historical perspective (between 1500 and 2000). This exploration encompasses a critical and relational understanding of the history of the scientific study of insects (entomology) and the processes of imperial expansion and global territorialization. To achieve this, students will learn how human-insect interactions led to radical transformations in diverse environments, reflecting a particular modern conception of nature influenced by control anxieties related to economic profit and tropical diseases. Moreover, students will examine how ways of knowing about insects and the environment were influenced by broader correlated economic and imperial factors. Focusing on insect (hi)stories, the aim of this seminar is to apply new methodologies for non-human agencies and source analysis on both micro and macro scales in global and environmental histories.

851-0304-00L  Science Fiction  W  3 credits  2S  A. Kilcher, S. Lohmann

Abstract
Literature in general can be seen as fundamentally concerned with the forms and functions of knowledge and (sometimes scientific) understanding, but the genre of science fiction is unique in that it literalises this approach in a far-reaching fashion as the future of science and technology. We will explore knowledge, and the "science of literature" through a diverse range of science fiction texts.

Objective
- Concept and history of science fiction
- Theory of science fiction and related forms (e.g. utopia, fantasy)
- Contexts of the history of knowledge and technology in the 19th and 20th centuries.
- Potential of science fiction to criticise technology and society

Content
This course introduces students to the various forms and functions of knowledge and science in literature, particularly within the realm of science fiction, the genre that most directly epitomises this fundamental connection within literary texts. In analysing how it shifts our understanding of ourselves and of supposedly inalterable facts about the reality we inhabit, we will examine how science fiction demonstrates that fiction is neither fundamentally in conflict with scientific knowledge, as previously supposed, nor a mere vehicle for its celebration, as still commonly presumed of science fiction. Instead, the genre, with its radical investigations into other forms of being, fearing and hoping, plays a crucial role in the social formation, order and negotiation of knowledge. As such, science fiction also represents a vital thought experiment regarding the "science of fiction", i.e. the development of a knowledge of literature and the many fascinating ways in which it helps us to know our own world better, in turn.

In this course, we will take a systematic and theory-based approach to a deeper understanding of science fiction, particularly concerning its historical roots, unique aesthetic/narrative tools, and relationship with the critical and technocultural contexts that shape it. Employing contemporary theoretical approaches, we will discuss a variety of themes within primary texts alongside diverse critical sources, all of which ultimately relate to knowledge and knowability. Particular areas of focus may include: other worlds and alien existences; altered temporality and alternate history; utopia and dystopia; climate fiction and the Anthropocene; trans- posthumanist and cyborg identities; robots and AI; and alternative futurisms. Moreover, the course will thereby also engage with the fundamental (and at times overlooked) role of order and presentation of knowledge, i.e. its aesthetic and narrative forms, within science and literature.

851-0125-65L  A Sampler of Histories and Philosophies of Mathematics  W  3 credits  2V  R. Wagner

Particularly suitable for students D-CHAB, D-INFK, D-ITET, D-MATH, D-PHYS

Abstract
This course will review several case studies from the ancient, medieval and modern history of mathematics. The case studies will be analyzed from various philosophical perspectives, while situating them in their historical and cultural contexts.

Objective
The course aims are:
1. To introduce students to the historicity of mathematics
2. To make sense of mathematical practices that appear unreasonable from a contemporary point of view
3. To develop critical reflection concerning the nature of mathematical objects
4. To introduce various theoretical approaches to the philosophy and history of mathematics
5. To open the students' horizons to the plurality of mathematical cultures and practices

Competencies
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Sensitivity to Diversity fostered
- Personal Competencies: Critical Thinking fostered

851-0455-00L  Science, Trust and Politics  W  3 credits  2S  G. Dorthe

Abstract
The seminar aims to inspire a nuanced understanding of the dynamics of expertise in society. Cross-fertilizing literature from science and technology studies (STS) and from activists’ movements, it focuses on contemporary controversies around emerging technologies and climate policy, where trust in science is said to be undermined (e.g. climate skepticism or anti-vaccine movements).

Objective
1) Introduce to the role and functions of expertise in democratic societies. 2) Familiarize with assumptions about science and society embedded in contemporary controversies. 3) Inspire critical perspectives on (dis)trust in science through activists’ movements on contested environmental and technological issues. 4) Develop a creative position on the relations between science, trust and politics.
Content

Engineers and scientists often pursue their studies and research in the hope that their knowledge can contribute to make a better world, inform democratic deliberation and help public understanding of complex issues. Yet this special status of science and technology is being increasingly contested by marginalized publics, lobbying, exposed populations, and by members of the scientific communities themselves. Climate skepticism or vaccine hesitancy are some of the most vivid examples of this confusing situation. In this seminar, students will learn to reflect on expertise as a form of scientific engagement in the messiness of democratic deliberation and public life, beyond the noble but outdated ideal of “speaking truth to power”.

The exercise of expertise is stumbling upon several conundrums. Which knowledge is relevant in which situation? How to make sure that some crucial perspectives are not left in the shadows? How to identify representative experts and make sure that they speak on behalf of a structured community? Whose voices are being silenced? On the other side of the spectrum, the public is often said to lack proper understanding of science and thus in need of being educated or disciplined. Or it is suspected of being manipulated by lobbyists or foreign hostile powers, or of being too attached to its own privileges and unwilling to act in favor of the common good. Whose agency is being acknowledged in sociotechnical controversies and whose agency is being denied and why? The seminar will provide a deep understanding of these perspectives, by putting them in a broader historical and epistemological context. Students will thus learn to critically assess their strengths as well as their blind spots.

Whereas opposing technological developments (anti 5G or anti-vaccine activists) or pushing to act accordingly to science (pro climate movements such as Extinction Rebellion or Scientist Rebellion), activists’ movements make up for a rich field of investigation on the dynamics of expertise and of how various publics can make sense of scientific knowledge. Cross-fertilizing activist’s texts and experiences with literature in science and technology studies and anthropology, this class will be organized as a structured conversation and a collective mapping of actors and key concepts of sociotechnical controversies. Over the course of the semester, students will learn not only to navigate some of the most heated contemporary debates, but also to articulate their own position on an issue of their choice.

Competencies

Subject-specific Competencies

Method-specific Competencies

Social Competencies

Communication

Cooperation and Teamwork

Sensitivity to Diversity

Negotiation

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Self-awareness and Self-reflection

Assessed

Fostered

Fostered

Fostered

Fostered

Fostered

Fostered

Fostered

Fostered

851-0541-00L

Truth and Historical Injustice: The Production of Knowledge about Past Mass Atrocities

W

3 credits

2V

S. M. Scheuzger

Abstract

The course deals with the scientific production of knowledge about past mass atrocities. It looks at the interplay of different disciplines, methods and technological means that have been involved in this production over time. Further, it poses the question of what truth can mean in this context.

Objective

The students a) know the main features of the discussion about the truth in the reconstruction of past events; b) have an understanding of the interplay, but also the coexistence of different scientific methods and technological means in the multidisciplinary production of knowledge about past mass crimes; c) have knowledge of important processes of dealing with past mass crimes from the second half of the 20th century onwards.

Content

When discussing the truthfulness of the academic study of the past, politically and ideologically motivated mass crimes are often cited as historical events in order to substantiate the necessity of a claim to truth. In doing so, moral arguments can be made or historical truth can be asserted as a basic prerequisite for living together in a democratic society under constitutional conditions. The production of knowledge about past atrocities has always been an endeavour in which various scientific disciplines have been involved. The multidisciplinary character of the production of knowledge about mass crimes has become even more accentuated since the second half of the 20th century, not least due to the emergence of new technological possibilities.

The course offers a brief introduction to the discussion about the meaning of truth about past events. It looks at how different scientific approaches - from the humanities to the natural sciences - have been involved in coming to terms with mass crimes and how they have been related to each other. It deals with the question of what role certain techniques and technologies have played in the production of knowledge about past atrocities and how this has changed over time. These techniques and technologies range from the evaluation of documents and the taking of testimonies to specialised database programs, genetic analysis or imaging techniques, to digital technologies.

In addressing these questions, the course looks at processes of dealing with the past from the middle of the 20th century to the 21st century in Europe, Latin America and Africa.

Competencies

Subject-specific Competencies

Concepts and Theories

Analytical Competencies

Techniques and Technologies

Critical Thinking

Assessed

Fostered

Fostered

Fostered

Fostered

Fostered

851-0456-00L

Research in Ethics, Technology and Society

W

2 credits

2S

M. Boenig-Liptsin, G. Dorthe

Abstract

Through thematic discussions of readings, presentation and workshop of writing-in-progress, and discussions with invited guests, this course brings together advanced students doing research in science, technology and society to develop their knowledge and projects in community with peers, postdoctoral fellows, and faculty.

Objective

The objective of the course is to provide students doing their own research on topics in science, technology and society with focused peer-feedback and tailored theoretical and methodological discussions to support the development of their projects.

Content

The course is focused on content from STS and moral and political theory and develops empirical, qualitative, and interpretive social science methods, such as ethnography/participant observation, historical archival research, discourse and document analysis, and semi-structured interviews. Specific thematic, reading, methodological foci are determined by the group to meet the specific needs of each participant.

Competencies

Subject-specific Competencies

Concepts and Theories

Analytical Competencies

Communication

Creative Thinking

Assessed

Fostered

Fostered

Fostered

Fostered

851-0392-00L

Privacy Quantification and Usable Protection Mechanisms

W

3 credits

2S

N. Zufferey, V. Zimmermann

Abstract

Students will gain an overview of the main privacy metrics that are used to evaluate privacy risks related to the use of a given technology. They will also be introduced to the concepts of privacy/utility balance and usable security. Practical exercises and reading of recently published scientific articles will be used to present practical cases of the theoretical tools presented in class.

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Autumn Semester 2024
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This course aims to provide the students with a global knowledge of the concepts related to privacy, and the methodology and tools to identify, analyze, and address threats while taking the user into account in the process. They will adopt a "privacy mindset", thus enabling them to automatically take privacy into account, in a usable way, when designing or analyzing a system.

First, the course will introduce the different definitions and approaches of privacy (e.g., privacy by control, privacy by design) as well as the ethical concerns and considerations related to information security and privacy research (e.g., responsible disclosure, full disclosure).

Second, the students will be introduced to the different methods, properties, and metrics to assess and/or guarantee a certain level of privacy. They will be introduced to the properties and metrics related to anonymization (e.g., k-anonymity, l-diversity), data aggregation (e.g., randomized responses, ε-differential privacy), as well as other privacy assessment methodologies (e.g., inferential privacy).

Third, the course will address usability issues and the role of individuals (i.e., users) in privacy management (i.e., usable security and privacy) and the design of privacy-enhancing technologies. In this context, we will analyze the main concepts seen during the course and discuss their advantages and disadvantages in terms of usability, as well as their implementation for mass-market and large-scale technologies.

Across all three parts of the course, practical exercises, as well as recent research articles reading, and presentations will be used as a complement to support the concepts seen in class, as well as to provide concrete examples of methodologies related to the assessment of privacy in general.

### Literature


### Competencies

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### Objective

Introduction to the History of Technology: Concepts, and Current Debates

Does not take place this semester.

Abstract
Technology and society cannot be separated: No society functions without technology. The seminar offers a problem-oriented introduction to basic questions of the history of technology, introduces approaches to the history of technology and discusses selected, ongoing debates.

Objective
The course seeks to provide a critical introduction to the issues, methods, and selected areas of research in the history of technology.

Content
History of technology investigates technological developments that arise in specific historical contexts. These developments are perceived by social groups or entire societies as a means of social change and ultimately find use or are forgotten. The questions that history of technology poses derive from the technological and social change that are a product of contemporary orientation and thinking; current historiographical methods provide the tools for answering these questions.

### Objective

Understanding in Science and Mathematics: A

Philosophical Perspective

Abstract
Understanding is a central goal of science and mathematics, but what exactly is the nature of scientific and mathematical understanding? In this seminar, we will read and discuss a number of key philosophical contributions on understanding in philosophy of science, philosophy of mathematics, and epistemology. You will also practice your skills in giving clear and engaging oral presentations.

Objective
The main objective of this seminar is to gain an in-depth understanding of the recent literature on understanding in the philosophy of science, the philosophy of mathematics, and epistemology. Another practical objective is to increase your skills in giving clear and engaging oral presentations.

Content
Understanding is a central goal of science and mathematics: scientists seek to understand various phenomena in the natural world, while mathematicians aim to increase our understanding of the mathematical world. But what exactly is the nature of understanding in science and mathematics? This issue has been largely neglected in twentieth century philosophy of science, philosophy of mathematics, and epistemology. Yet, in the past twenty years, there has been a regain of philosophical interest into the notion of understanding, leading to a flourishing literature. The aim of this seminar is to gain an in-depth understanding of these recent philosophical developments.

To this end, we will read a number of key philosophical contributions on understanding in philosophy of science, philosophy of mathematics, and epistemology. Along the way, we will address general issues on understanding such as: What is the relation between understanding and knowledge? Does understanding necessarily require explanation? How can understanding be transmitted? What exactly is the value of understanding? We will also look into specific case studies of scientific and mathematical understanding.

Each session will be decomposed into three blocks. In blocks 1 and 2, we will have a short presentation (~15 minutes) of a contribution in the philosophy of understanding followed by a discussion. Block 3 will be methodological and will be concerned with how to give good oral presentations, an essential skill in academia. We will use this block to debrief on the presentations of the day and see how they could be improved. We will also discuss resources on best practices in oral communication.
Since the dawn of time mankind has tried to exert influence over others through the utilisation of certain techniques: initially for self-preservation – for example the interpretation of Sigmund Freud in Totem and Tabu. Later, desire became the driving force – centre stage: the desire for pleasure, power and control. Manipulation manifests itself in the form of characters and words, it is an authentically linguistic occurrence: classical antiquity, with the rhetoric, develops a system of verbal power of persuasion and, already then, questions were being raised in literary and discursive texts about how people could, or even should, manipulate. The exertion of influence and its impact will be clearly described, propagated, commented upon, criticised and ironised. In contrast to oppressive overpowering, the power of manipulation (in Latin, manus hand, plere fill) is on the one hand, based on the subtle use of persuasive linguistic elements – it is always a (literary) discourse, too – and on the other, on knowing precisely what the fantasies, desires and fears of the manipulated are. The discourse of manipulation has its beginnings in the age of sophists and their belief in an omnipotence of language and rhetoric. It underwent further transformation under political and psychological signs in the early modern period through Giordano Bruno and Niccolò Machiavelli and culminated in the 20th century in a critique of the deception strategies of the ‘culture industry’ (T.W Adorno) and ‘psychotechnology’ (B. Stiegler) in global capitalism. Nowadays social media is the ‘radicalisation machine’ (J. Eben) that present new challenges for society. Written in the 19th century, the Protocols of the Elders of Zion already gave indications of how present-day conspiracy theorists would manipulate their audience, and its impact can still be felt today. Since manipulation is a linguistic, narrative and also literary phenomenon, the central theme of the lecture is how in literature itself this often politically controversial and manipulative behaviour is picked up and reflected through poetry: such as in Tristan from Gottfried von Strassburg, Goethe’s Wilhelm Meister, Friedrich Schiller’s Die Verschwörung des Fiesco zu Genua or Heinrich von Kleist’s Der zerbrochne Krug, the works of Edgar Allan Poe and Thomas Mann (Mario und der Zauberer) and, most recently in Eckhart Nickel’s novel, Hysteria.

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**851-0018-00L Doctoral Colloquium in History of the Modern World**

**W 1 credit 1K E. Valdameri**

**Abstract**

In this colloquium, doctoral students can present their research plan, share a chapter of their thesis, discuss a problem they are facing with their sources, etc. They obtain feedback by postdocs as well by the peer students taking part in the colloquium.

**Objective**

Obtain feedback on the doctoral research plan as required by ETH Zurich, when applicable, as well as on their research at large.

**Content**

Doctoral students from the Chair of the History of the Modern World attend this colloquium every semester, during which they present their research according to their PhD stage. All students are supposed to read and comment on their peers’ research ideas and plans throughout both semesters. A one-off 1 ECTS can be credited to registered students. At the end of the second semester, students present their work (the research plan or a 5000-word article) in front of the entire team and two external commentators.

**Transferable Skills**

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Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0104-DRL Transferable Skills Course II (1-3 days, with Poster or Talk) Only for doctoral students. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0105-DRL Transferable Skills Course III (1-3 days, with Poster or Talk) Only for doctoral students. Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0106-DRL Transferable Skills Course I (1 week) Only for doctoral students. Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

900-0107-DRL Transferable Skills Course II (1 week) Only for doctoral students. Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

900-0108-DRL Transferable Skills Course III (1 week) Only for doctoral students. Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

900-0109-DRL Transferable Skills Course I (1 week, with Poster or Talk) Only for doctoral students. Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL Transferable Skills Course II (1 week, with Poster or Talk) Only for doctoral students. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.
Active participation in the presidium or executive board of a university group for at least 1 year. 

1 credit

Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Member of Executive Board (min 1 year) 

Lecturers

Participation in Commission II (min 1 year)

Lecturers

Participation in Commission I (min 1 year)

Lecturers

Transferable Skills Course III (1 week, with Poster or Talk)

Lecturers

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

4P

Transferable Skills Course III (1 week, with Poster or Talk)

Lecturers

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

8P

Ethics and Scientific Integrity for Doctoral Students

G. Achermann

This course is interdisciplinary. If your department offers this course, please register there if possible.

1 credit

Part I on Moodle

The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II

The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students. For doctoral students only.

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).
## Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Method-specific Competencies</th>
<th>Decision-making</th>
<th>Problem-solving</th>
<th>Personal Competencies</th>
<th>Critical Thinking</th>
<th>Integrity and Work Ethics</th>
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## Integration into Scientific Community

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<th>Number</th>
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**Doctorate Humanities, Social and Political Sciences - Key for Type**

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<th>Code</th>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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### Key for Hours

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<td>G</td>
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<td>exercise</td>
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<td>practical/laboratory course</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Subject Specialisation

#### Health Sciences and Technology

<table>
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<td>376-0302-01L</td>
<td>GCP Basic Course (Modules 1 and 2)</td>
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<td>1</td>
<td>1G</td>
<td>G. Senti, C. Fila, R. Grossmann</td>
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</table>

**Abstract**
The basic course in "Good Clinical Practice" (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

**Objective**
- Students will get familiar with:
  - Key Ethics documents
  - (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
  - Sequence of research projects and project-involved parties
  - Planning of research projects (statistics, resources, study design, set-up of the study protocol)
  - Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
  - Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

**Content**
Module 1:
- Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
- Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

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<td>Colloquium in Translational Science (Autumn Semester)</td>
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<td>A. Alimonti, V. Falk, J. Goldhahn, K. Maniura, R. M. Rossi, S. Schürle-Finke, G. Shivashankar, E. Vayena, V. Vogel</td>
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</table>

**Abstract**

**Objective**
- Getting insight into actual areas and problems of translational medicine.

**Content**
Timely and concise presentations of postgraduate students, post-docs, senior scientists and professors, as well as external guests from both academias and industry will present topics of their interest related to translational medicine.

**Prerequisites / notice**
No compulsory prerequisites, but students should have basic knowledge about biomedical research.

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<td>V. Falk</td>
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</table>

**Abstract**
Does not take place this semester.

**Objective**
- Deeper, mutual understanding of current medical challenges and technical solutions in cardiovascular medicine.

**Content**
Timely and didactically structured presentations of postgraduate students, post-docs, senior scientists and professorson topics from Zurich Heart / ETheart projects, followed by lectures on chosen topics of cardiovascular medicine and research given by leading international clinical scientists in the field.

**Prerequisites / notice**
No compulsory prerequisites, but students should have basic knowledge about cardiovascular system, physiology and biomedical research.

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<td>4</td>
<td>3G</td>
<td>C. Menon, C. Ahmadizadeh, C. Oteteanu</td>
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**Abstract**
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

**Objective**
- Objective 1:
  - Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.
- Objective 2:
  - Acquire skills to design novel non-invasive technologies for sport and health.

**Content**
The course consists of two modules.

**Module 1: Movement.**
This module provides the scientific background needed to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies.

**Module 2: Cardiac.**
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies and the latest data analysis techniques to monitor the cardiac cycle for assisting individuals in sport activities or monitoring their health conditions.
The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience. The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.

Prerequisites /
notice
- Students should be proficient in programming (any language).
- Note: assignments will be in MATLAB. Students are expected to learn MATLAB on their own if not experienced with this programming language.
- Course prerequisites:
  - For Biomedical Engineering Master’s: none
  - For ITET Master’s: none
  - For D-MAVT Master’s: none
  - For D-HEST Master’s and PhD students:
    - If BSc in electrical/mechanical engineering or computer science: none
    - If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)

376-1791-00L

Introductory Course in Neuroscience I (University of Zurich)

W 2 credits 2V

W. Knecht, University lecturers

Objective
1) Human Neuroanatomy I&II
2) Comparative Neuroanatomy
3) Building a central nervous system I&II
4) Synapses I&II
5) Glia and more
6) Excitability
7) Circuits underlying Emotion
8) Visual System
9) Auditory & Vestibular System
10) Somatosensory and Motor Systems
11) Learning in artificial and biological neural networks

For doctoral students of the Neuroscience Center Zurich (ZNZ).

Prerequisites /
notice
Required classes:
- 401-0643-00L Statistik I
- 401-0643-13L Statistik II
- 376-1983-00L Foundations of Data Science

Recommended courses:
- 252-0842-00L Programmieren und Problemlösen

376-1794-00L

Colloquium in Biomechanics

W 2 credits 2K


Objective
Current topics in biomechanics presented by speakers from academia and industry.

Getting insight into actual areas and problems of biomechanics.

701-0015-00L

Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement

W 2 credits 1S

B. Vienni Baptista, C. E. Pohl, M. Stauffacher

The lecture takes place if a minimum of 12 students register for it.
Abstract
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

Objective
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, or how to secure broader impact of research. They learn to critically reflect their own research project in its societal context and on their role as scientists.

Content
The seminar covers the following topics:
(1) Theories and concepts of inter- and transdisciplinary research
(2) The specific challenges of inter- and trans-disciplinary research
(3) Collaborating between different disciplines
(4) Engaging with stakeholders
(5) 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed and with practical tools explored in class to address concrete challenges.

Literature
Literature will be made available to the participants.

The following open access article builds a core element of the course:

Further, this collection of tools will be used:
https://naturalsciences.ch/topics/co-producing_knowledge
https://www.shapeittoolkit.eu

Prerequisites / notice
Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00)

Food Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-0005-00L</td>
<td>Colloquium in Food and Nutrition Science</td>
<td>W</td>
<td>1</td>
<td>2K</td>
<td>S. J. Sturia</td>
</tr>
</tbody>
</table>

Abstract
Participation in weekly seminars on a variety of topics including Food Microbiology, Food Toxicology, Food Biochemistry, Food Processing, Consumer Behavior, Food Technology, and Food Materials and Technology, and oral presentation of a selected published study in one of these areas inspired by participation in the seminars.

Objective
The objectives are to become familiar with and stimulate interest in leading-edge science related to the research topics of the Institute of Food, Nutrition and Health. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the semester presentations.

Transferable Skills

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<td>376-1664-00L</td>
<td>Ethics in Drug Development</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Blasimme, E. Vayena, to be announced</td>
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</table>

Abstract
This course provides a thorough exploration of drug development and involved ethical issues as well as critical analysis of ethical challenges and practical skills to resolve them. It includes elements of drug discovery, preclinical and clinical research ethics, alternative regulatory pathways and ethics of drug pricing and develops a solid grasp of ethical complexity as well as practical skills.

Objective
This course is tailored to D-HEST students who want to become familiar with pharmaceutical development and its ethical implications. By the end of this course, students will have developed a comprehensive understanding of the ethical complexities and challenges in drug development. They will be equipped with the knowledge and analytical skills to navigate ethical reasoning and contribute to the responsible advancement of pharmaceutical research. The specific learning objectives of the course are:

- Discuss relevant legal and public policy frameworks in drug development, ensuring an understanding of the broader regulatory context within which policy and regulatory decisions are made.
- Identify and discuss ethical issues in drug development in light of recent advances in the field of artificial intelligence.
- Critically analyze ethical challenges within drug development, enabling them to discuss complex issues, evaluate competing ethical perspectives, and form reasoned judgments.
- Understand the ethical theories and principles that underpin drug regulation.
- Evaluate the ethical implications of alternative pathways, such as Accelerated Approval and Compassionate Use, equipping students to assess potential benefits, risks, and societal consequences.
- Assess the ethical dimensions of drug pricing decisions and their impact on equity and accessibility, encouraging thoughtful reflection on the broader societal implications of pricing strategies.

Content
- Principles of biomedical ethics and how they relate pharmaceutical innovation
- Introduction to drug development, with a focus on the Swiss regulatory ecosystem
- Current trends and impediments to effective drug development, including the use of AI in drug discovery
- Translational medicine and its ethical implications
- Ethical Aspects of pre-clinical research, including animal replacement technologies like organoids and organ chips
- Ethical aspects of clinical research
- Special regulatory pathways: expanded access / compassionate use
- Special regulatory pathways: accelerated approval
- Drug development and public health. emergency use of new drugs
- Drug pricing: introduction to its regulatory and ethical aspects
Health Sciences and Technology

Only for doctoral students D-HEST.

Abstract
This course allows D-HEST PhD students to fulfill the requirements of the mandatory training in ethics. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objective
The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in relation to human health. The specific learning objectives of this course are:

- Identify ethical issues in life sciences and biotechnology.
- Analyze and critically discuss ethical issues in life sciences and biotechnology.
- Become aware of relevant legal and public policy frameworks.
- Distinguish different ethical approaches and argumentative strategies in applied ethics.
- Recognize how ethical issues relate to different accounts of technology and innovation.
- Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
- Autonomously anticipate ethical issues.
- Propose and communicate solutions to ethical challenges and dilemmas.

Content
This course allows the students to autonomously decide among a broad list of topics specifically designed to be aligned with the scientific interests of D-HEST doctoral programs.

The course has three components:
1) Students will watch pre-recorded material that will be made available on Moodle.
2) Students will attend an introductory lecture on the ethics of science, technology and innovation.
3) Students will choose two lectures to attend from a list of thematic lectures that will take place throughout the semester.

Competencies

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<tr>
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<th>Method-specific Competencies</th>
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<tr>
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851-0745-00L
Ethics Workshop: The Impact of Digital Life on Society

Open to all Master level / PhD students.

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Objective
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.

Content
The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

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851-0178-00L
Ethics and Scientific Integrity for Doctoral Students

This course is interdisciplinary. If your department offers this course, please register there if possible.

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.
Part I on Moodle
The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only.

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

Competencies
Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Decision-making assessed

Personal Competencies
Critical Thinking assessed
Integrity and Work Ethics assessed

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<td>Transferable Skills Course I (1-3 days)</td>
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<td>900-0104-DRL</td>
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Abstract: Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

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<td>900-0108-DRL</td>
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<tbody>
<tr>
<td>900-0109-DRL</td>
<td>Transferable Skills Course I (1 week, with Poster or Talk)</td>
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<td>Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.</td>
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**Integration into Scientific Community**

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and prove your participation with the appropriate certificate.

**Abstract**
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

**Objective**
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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External Conference III (incl. Poster or Talk)  

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective  
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Doctorate Health Sciences and Technology - Key for Type

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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Courses outside the curriculum</td>
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Key for Hours

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<td>A</td>
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<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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ECTS  
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Subject Specialisation

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<td>227-0811-00L</td>
<td>Creative Thinking Seminar</td>
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<td>A. C. Notz</td>
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<tr>
<td>Abstract</td>
<td>This seminar aims to understand better what creativity and creative thinking is by looking at the history of the creativity dispositive we are embedded in. We will look, learn and apply creative artistic practices to find innovative solutions. And we will also look beyond the artistic practices, into the creative potential of today's technologies, especially Generative AI.</td>
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<td>Objective</td>
<td>The students will gain insights into the concept and mechanics of Creative Thinking. They will trace the historical roots of creativity and its contemporaneous significance, explore how Creative Thinking intersects with modern innovations and technologies. The students will develop a comprehensive understanding of Creative Thinking and its practical application, start to cultivate the ability to generate innovative solutions through creative practices and will analyze the broader implications of creativity in various contexts.</td>
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<td>Content</td>
<td>In the business world Creative Thinking is considered to be one of the &quot;top ten skills&quot; or &quot;most In-Demand skill&quot; in 2024. With Creative Thinking innovative solutions to problems are developed and not only a large number of ideas but also a variety and range of them are brainstormed. It seems that in today's dynamic world, creativity isn't just an asset – but actually necessity. But what exactly is Creative Thinking? In the above mentioned business context it is assumed everybody knows. And what is creativity? And how can we use it. Or not. Originally, connected to artistic practice, creativity is nowadays a skill and practice that can be found in all work areas, especially innovation and maybe even in technological applications themselves. Today, not only because of creative economy, creative cities or innovation, but also because of generative AI creativity has gained new and broad attention. In the seminar we go back in history to the invention of the genius and look at different social subsystems like art, psychology, economy as well as field as fashion, advertisement and arts and crafts, how our understanding of creativity has emerged till today.</td>
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<td>252-4202-00L</td>
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<td>A. Steger, B. Gärtner, M. Hoffmann, J. Lengler, D. Steurer</td>
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<tr>
<td>Abstract</td>
<td>Presentation of recent publications in theoretical computer science, including results by diploma, masters and doctoral candidates.</td>
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<td>Objective</td>
<td>The goal is to introduce students to current research, and to enable them to read, understand, and present scientific papers. This seminar takes place as part of the joint research seminar of several theory groups. Intended participation is for students with excellent performance only. Formal restriction is: prior successful participation in a master level seminar in theoretical computer science.</td>
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<td>263-3010-00L</td>
<td>Big Data</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>G. Fourny</td>
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<tr>
<td>Abstract</td>
<td>The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations. The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the &quot;fourth paradigm&quot;. Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small. The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.</td>
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<td>Objective</td>
<td>Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts. &quot;Big Data&quot; refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the &quot;fourth paradigm&quot;.</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 787 of 2667
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (? , *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Abstract

Venture Capital is important to fund big transformational ideas and is often misunderstood by tech or research entrepreneurs. This lecture immerses participants in the role of a Venture Capitalist (VC) to learn from experienced entrepreneurs and investors. In small teams, you work on a case of a real start-up and defend the case in a simulated investment committee consisting of experienced VCs.

After attending this course, students will be able to:
- Explain the differences between VC and founder thinking
- Evaluate if a start-up is suited for venture capital ("VC readiness")
- Evaluate founder friendliness of term sheets
- Determine funding needs & strategy for a start-up from research to first round
- Write and evaluate an investment memo

Objective

263-5053-00L Technology Investing W 2 credits 3S A. Ilic, C. Jurytko

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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- Write and evaluate an investment memo
Content
The course is practically oriented and features guest speakers from leading venture capital firms and start-ups. The course embraces a unique perspective combining technology and investor thinking. The seminar is structured around five days with the following themes.

The detailed program is listed here: https://bit.ly/techinvesting23

The macro picture. Why does venture capital exist? What are major tech break-through areas and their disruptive potential? We also review the differences in the US and European perspective as well as developments towards more impact and diversity conscious funds.

A peek into the mind of a VC. How to build a successful VC? Learn what key factors & processes required to build a successful venture capital company. This includes strategic decisions for investment thesis, structure of a fund, portfolio economics, valuation & ownership targets, cap table. In addition, we introduce the fundamentals of the investment process (including due diligence, term sheets, and deal memo) as well as portfolio management.

The founder’s perspective. Why should you raise venture capital and how? Learn to evaluate the founder friendliness of terms, company approach, strategic decisions, negotiation and valuation.

Fundraising types. Learn about different types of funding and their implications. This includes an overview of the Swiss ecosystem and a discussion of the different types (grants, equity, loans, SAFE, crowd, …). We also include a practical session on crypto technology for modern fund-raising using launchpads and tokenized shares.

Tying it all together. The last day is focused on simulating an investment committee meeting where the groups present their deal memos and discuss with the audience.

Competencies
Subject-specific Competencies
- Concepts and Theories: fostered
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed

263-5054-00L Patenting Digital Innovations

Abstract
In this seminar dedicated to digital innovations, we will bust the most stubborn myths around AI software patents such as “Software/Al isn’t patentable”, “AI patents are useless because you can’t figure out if they are infringed”, and many others. We will look at how AI and software start-ups can use patents to create a strong IP position in a scalable way.

Objective
After attending this course, students will be able to:
- Understand the basics of patenting in the digital space relevant for a global market
- Evaluate patenting opportunities with a more differentiated view on the topic
- Effectively use patents as a cost-effective part of a technology startup’s business plan
- Conduct patent searches, freedom-to-operate analysis and infringement analyses
- Write their first software/Al-related invention disclosure suitable for patenting

Content
The course is focused on patenting digital innovations. It is designed for students with entrepreneurial interests that like to get a hands-on perspective on the topic of intellectual property strategies and patents.

The seminar includes presentations and practical group exercises to apply the acquired knowledge in practice. Entrepreneurs and leading IP experts are joining the seminar as guest speakers for discussion of real-life examples.

Topics that will be covered include:
- Best practices that any AI/software startups should know about IP and patents
- How investors evaluate a strong IP situation of a start-up
- How to efficiently monitor competitor patent activity and obtain “FTO”
- How to create an effective patent filing strategy that grows with the business
- How to efficiently create AI patents while not getting distracted from the founder’s core business

The course also contains a group work of a “FTO battle” where two teams compete in a freedom-to-operate analysis and individual work to write their first invention disclosure related to an AI or software topic.

263-5057-00L From Publication to the Doctor’s Office

Abstract
This seminar course is designed to provide students with an opportunity to review and critically evaluate recent publications in medical field focusing on examples when CS method or bioinformatics/statistical technique has lead to an instrumentation, technique or drug approved for clinical practice use.

Objective
Throughout the course, students will read and analyze recent publications that demonstrate successful applications and sometimes failures in medicine. Promising research applications will also be discussed. The publications will cover a wide range of topics, including drug discovery, image analysis, prognostic models, and learning healthcare.
The course will be structured as half lecture content and half seminar content. Lectures will review state of the medical practice prior to the discovery, obstacles in moving the field forward, and the need for improvement. Lecture will be followed by the seminar part where students will take turns presenting the assigned publications and leading the discussions. Students' presentations will focus on the main findings, and specific steps taken to translate the finding into clinical practice.

Publications will include examples of:
- specific CS/bioinformatics/statistics applications that has been brought to “bedside” – has been approved by European Medicines Agency / Food and Drug Administration (USA) for clinical use or are widely used in medical research;
- examples of failures of how a discovery did not translate into an endproduct and why;
- current active research areas.

Covered topics will include some of the following:
- Drug discovery: Computer-aided drug discovery has become an integral part of the drug development process, enabling researchers to design and screen large libraries of molecules in silico (i.e., using computer simulations) before synthesizing and testing them in the lab. This has led to the discovery of new drug candidates for a wide range of diseases, including cancer, Alzheimer’s disease, and HIV/AIDS.
- Genomics: Advances in computational genomics have enabled researchers to analyze and interpret large-scale genomic data, including DNA sequencing data, to identify disease-causing mutations, genetic risk factors, and drug targets. Examples of the development of personalized medicine, where treatments are tailored to an individual’s genetic makeup. Examples when drug target identified by genetics has led to approved treatment.
- Imaging: Computer vision and image processing techniques have revolutionized medical imaging, enabling researchers to extract quantitative information from medical images that were previously inaccessible. This has led to the development of new diagnostic and prognostic tools for a wide range of diseases, including cancer, cardiovascular disease, and neurological disorders.
- Real-world data applications: emulation of clinical trials using electronic health records data.
- Large language models: Generating clinical trial protocols using large language models. Natural Language Processing for information extraction and interpretation.
- Learning healthcare systems: Advances in data analytics and information technology have enabled the development of learning healthcare systems, which use real-time data from electronic health records, medical devices, and other sources to improve patient outcomes and reduce healthcare costs. This has the potential to transform the way healthcare is delivered, making it more personalized, efficient, and effective.

In addition to the presentations, students will also be required to write critical reviews of the assigned publications throughout the course. The reviews will be evaluated based on the students’ ability to identify the strengths and weaknesses of the publications and to provide insightful and constructive feedback.

Prerequisites / notice
The course is intended for advanced undergraduate and graduate students with a background in computer science, bioinformatics, or a related field and interest in applying their skills to medical research.

This course assumes a working knowledge of R/Python and intermediate statistical analysis, including linear, logistic, survival regressions or ability and interest to learn them outside of the class.

Competencies

<table>
<thead>
<tr>
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</tr>
<tr>
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<td>Creative Thinking</td>
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</tbody>
</table>

263-5058-00L Technology and Entrepreneurship
W 3 credits 6S A. Illic

Abstract
This course provides theoretical and practical insights into technology entrepreneurship. It focusses on the process of building new ventures from the idea to successfully scaling its business operations.

Objective
Students will develop internationally scalable and technology-based ventures using the Startup Navigator and ScaleUp Navigator Framework. They will learn how to structure and communicate these ideas to business angel and venture capital investors.

Content
This course provides theoretical and practical insights into technology entrepreneurship. It focusses on the process of building new ventures from the idea to successfully scaling its business operations. All tasks will lead students to give a complete pitch presentation in front of business experts and investors at the end of the seminar. The course structure will broadly follow the four dimensions of the St.Galler Startup NavigatorTM.

- Profiling (Problem-Solution-Fit): Here, students will learn to answer questions such as (1) what is your motivation to start a business? (2) What is the real customer problem? (2) What solution can be identified? (3) Who are the customers? (4) What is the job they need done? etc.
- Prototyping (Product-Market-Fit): After this section, students will be able to answer questions such as (1) What is the product or service that solves a customer need? (2) What is the value proposition? (3) What is the unique selling proposition? (4) What is the go-to market strategy? (5) Who are the competitors? etc.
- Sourcing (Execution-Fit): Here, students will learn to address questions such as (1) What are important team roles? (2) How to leverage network and partners? (3) What are the requirements to execute the business? (4) Are there any IP-related challenges? (5) How may we co-create with others? etc.
- Scaling (Performance-Fit): In this section, students will reflect their concept in terms of scalability. They will learn to answer questions such as (1) How do we create purpose-driven culture for growth? (2) How do we scale-up revenues? (3) How do we optimize our startup's valuation in Series-X funding? (4) What kind of exit options are there?

As a result, students develop internationally scalable and technology-driven businesses in teams. The special focus lies on the ability to successfully pitch these ventures to business angels or venture capital investors.

Literature
- Course slides and case-based literature provided by the instructor.
- Additional material pointed out by the instructor prior to and during the course.
### Abstract
In this doctoral seminar, current research at the Institute for Visual Computing will be presented and discussed. The goal is to learn about current research projects at our institute, to strengthen our expertise in the field, to provide a platform where research challenges can be discussed, and to practice scientific presentations.

### Objective
Current research at the Institute for Visual Computing will be presented and discussed. The goal is to learn about current research projects at our institute, to strengthen our expertise in the field, to provide a platform where research challenges can be discussed, and to practice scientific presentations.

### Content
This course requires solid knowledge in the area of Computer Graphics and Computer Vision as well as state-of-the-art research.

### Prerequisites
- For 264-5812-00L: Doctoral and Research Writing in Computer Science A Z
  - Only for D-INFK doctoral students.
- For 264-5813-00L: Doctoral and Research Writing in Computer Science B Z
  - Only for D-INFK doctoral students.
- For 263-5907-00L: Geometry for Computational Design and Fabrication
  - The main intention of the course is to present geometric concepts that turned out to simplify the solution of problems in computational design and fabrication and hold promise to provide useful methodology for future research in this area.

<table>
<thead>
<tr>
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<th>Credits</th>
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<tr>
<td>264-5812-00L</td>
<td>Doctoral and Research Writing in Computer Science A Z</td>
<td>2 credits</td>
<td>1G</td>
</tr>
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<td>264-5813-00L</td>
<td>Doctoral and Research Writing in Computer Science B Z</td>
<td>2 credits</td>
<td>1G</td>
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<td>263-5907-00L</td>
<td>Geometry for Computational Design and Fabrication</td>
<td>1 credit</td>
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</table>

*Autumn Semester 2024*
### Content

Assuming some basic knowledge of elementary differential geometry of curves and surfaces in 3-dimensional Euclidean space, we will discuss concepts of classical constructive differential geometry and their discrete versions, with a focus on quadrilateral nets. Topics to be addressed include mappings between surfaces, conjugate parameterizations, principal parameterizations, developable surfaces and their applications in architectural structures, design of mechanical metamaterials and fabrication processes based on bending of material. Another focus is on geometric optimization problems, discussing mainly geometric ideas on initialization, regularization and the formulation of frequently appearing objective functions. A further topic is given by transformations which preserve important structures. This reaches into the sphere geometries of Möbius and Laguerre and transformations of nets. Finally, we present the basics of kinematical geometry, such as velocity fields and their use in registration algorithms, infinitesimal flexibility and the closely related static equilibrium of shells.

### Transferrable Skills

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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</tr>
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<tbody>
<tr>
<td>851-0178-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students</td>
<td>W</td>
<td>1</td>
<td>2U</td>
<td>G. Achermann</td>
</tr>
</tbody>
</table>

This course is interdisciplinary. If your department offers this course, please register there if possible.

### Abstract

This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

### Objective

Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

### Content

**Part I on Moodle**

The self-paced e-learning course on Moodle consists of 5 modules:

- **Module 1: Ethics**
  - Introduction to moral theory (with emphasis on practical guidance regarding decision making)

- **Module 2: Ethics in scientific research**
  - Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

- **Module 3: Collecting resources**
  - A variety of tools and resources that help identify ethical issues are presented and explained

- **Module 4: Setting up a strategy**
  - Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

- **Module 5: Making decisions**
  - Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

**Part II**

The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

### Prerequisites / notice

For doctoral students only. The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II).

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

### Competencies

- **Subject-specific Competencies**
  - Concepts and Theories
  - Decision-making
  - Problem-solving

- **Method-specific Competencies**
  - Critical Thinking
  - Integrity and Work Ethics

### Number

851-0373-00L

**Learning to Teach**

This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities.

### Abstract

This course imparts a variety of teaching skills which will help Doctoral Teaching Assistants with their teaching tasks.

### Objective

In this course Doctoral Teaching Assistants will ...

- discuss learning science and teaching techniques with peers.
- design the introduction of their course/lecture/exercise class.
- develop learning activities according to learning objectives.
- practice classroom assessment techniques in order to measure student learning.
- engage in peer feedback in order to improve own teaching.

### Content

We will meet for the mandatory kick-off meeting online in October. You will get detailed information together with the invitation email in the first week of the semester. The online phase, where you work through 6 modules in the Moodle course page will end in November. We will meet also face-to-face for the Consolidation workshop. You will find more information on the course page in Moodle.

The consolidation workshop will take place in November. Dates will be announced at the beginning of the semester.

### Prerequisites / notice

This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities (exercises, excursions, supervision of practicals, lectures, etc.) or those who will assume teaching tasks in the semester following the programme. No previous teacher training is required.
**Competencies**

Subject-specific Competencies
- Concepts and Theories: fostered
- Media and Digital Technologies: fostered

Method-specific Competencies
- Communication: fostered
- Cooperation and Teamwork: assessed

Social Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

Personal Competencies
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Negotiation: assessed

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered

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**851-0745-00L Ethics Workshop: The Impact of Digital Life on Society**

Open to all Master level / PhD students.

**Abstract**

This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

**Objective**

- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Work in a more ethically reflective way.

**Content**

The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

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**Competencies**

- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Communication: assessed
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Negotiation: assessed
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered

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**900-0100-DRL Transferable Skills Course I (1-3 days)**

Only for doctoral students.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**900-0101-DRL Transferable Skills Course II (1-3 days)**

Only for doctoral students.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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**900-0102-DRL Transferable Skills Course III (1-3 days)**

Only for doctoral students.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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**Course units in Humanities, Social and Political Sciences**

Educational Science for Teaching Diploma and TC

Language Courses ETH/UZH: see Science in Perspective

Course units in Management, Technology and Economics

**Lecturers**

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
### 900-0103-DRL
**Transferable Skills Course I (1-3 days, with Poster or Talk)**

- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
- **Abstract:** Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
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<td>900-0103-DRL</td>
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<td>1-3 days</td>
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</table>

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### 900-0104-DRL
**Transferable Skills Course II (1-3 days, with Poster or Talk)**

- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
- **Abstract:** Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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<td>1-3 days</td>
<td>2 credits</td>
<td>4S</td>
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</table>

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### 900-0105-DRL
**Transferable Skills Course III (1-3 days, with Poster or Talk)**

- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
- **Abstract:** Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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<th><strong>Semester</strong></th>
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<td>1-3 days</td>
<td>2 credits</td>
<td>4S</td>
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Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### 900-0106-DRL
**Transferable Skills Course I (1 week)**

- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.
- **Abstract:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.
- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

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Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### 900-0107-DRL
**Transferable Skills Course II (1 week)**

- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.
- **Abstract:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.
- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

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Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### 900-0108-DRL
**Transferable Skills Course III (1 week)**

- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.
- **Abstract:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.
- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

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Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### 900-0109-DRL
**Transferable Skills Course I (1 week, with Poster or Talk)**

- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.
- **Abstract:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.
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Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### 900-0110-DRL
**Transferable Skills Course II (1 week, with Poster or Talk)**

- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.
- **Abstract:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.
- **Objective:** Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

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<th><strong>Semester</strong></th>
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<td>3 credits</td>
<td>6S</td>
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</table>

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL Transferable Skills Course III (1 week, with Poster or Talk)

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL Participation in Commission I (min 1 year)

Only for doctoral students.

Abstract Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year)

Only for doctoral students.

Abstract Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year)

Only for doctoral students.

Abstract Active participation in the presidium or executive board of a university group for at least 1 year.

Objective Active participation in the presidium or executive board of a university group for at least 1 year.

► Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
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Objective Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0154-DRL Summer School II (1-3 days, with Poster or Talk) W 2 credits 4K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0155-DRL Summer School III (1-3 days, with Poster or Talk) W 2 credits 4K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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Objective Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0156-DRL Summer School I (1 week) W 2 credits 4K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 1 week.

Objective Participation in summer or winter schools with a minimum duration of 1 week.

900-0157-DRL Summer School II (1 week) W 2 credits 4K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 1 week.

Objective Participation in summer or winter schools with a minimum duration of 1 week.

900-0158-DRL Summer School III (1 week) W 2 credits 4K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 1 week.

Objective Participation in summer or winter schools with a minimum duration of 1 week.

900-0159-DRL Summer School I (1 week, with Poster or Talk) W 3 credits 6K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0160-DRL Summer School II (1 week, with Poster or Talk) W 3 credits 6K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0161-DRL Summer School III (1 week, with Poster or Talk) W 3 credits 6K Lecturers
Only for doctoral students.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.
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**Doctorate Computer Science - Key for Type**

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<th>Type</th>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
<td>Suitable for doctorate</td>
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<td>O</td>
<td>Compulsory</td>
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**Key for Hours**

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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**

- European Credit Transfer and Accumulation System
  - Special students and auditors need special permission from the lecturers.
### Subject Specialisation

The courses on offer below are only a small selection out of a much larger available number of courses. Please discuss your course selection with your PhD supervisor.

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6 credits</td>
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<td>H.-A. Loeliger</td>
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<td>227-0146-00L</td>
<td>Data Conversion System Design</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>T. Burger, G. Cervelli, R. Reutemann</td>
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<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6 credits</td>
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<td>J. Lygeros, A. Tsiamis</td>
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</table>

**Abstract**

- Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

**Objective**

- Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

**Content**

- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of regression methods
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

**Lecture notes**

- Lecture notes will be provided.

**Prerequisites / notice**

- Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control in Spring Semester) strongly recommended.
- Background in linear algebra and stochastic systems recommended.

**Abstract**

- Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

**Objective**

- Students master the basic mathematical concepts and algorithms of estimation and machine learning.

**Content**

- Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more

**Lecture notes**

- Lecture notes will be handed out as the course progresses.

**Prerequisites / notice**

- Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control in Spring Semester) strongly recommended.
- Background in linear algebra and stochastic systems recommended.

**Abstract**

- This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.

**Objective**

- Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. Students will learn the underlying principles of data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or algorithmic conversion are explained based on their operation principle accompanied with the appropriate mathematical calculations, including effects of non-idealities in some cases. After successful completion of the course students should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.

**Content**

- Introduction: examples of data conversion architectures; information representation; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy.
- Dual-slope & successive approximation register (SAR) converters: dual slope principle & converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.
- Algorithmic & pipelined A/D converters: algorithmic conversion principle; sample & hold stage; piped-line converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.
- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.
- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkle correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters; cascaded folding and interpolation.
- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.
- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-oder delta-sigma modulation, circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.
- Digital-to-analog converters: introduction; current scaling D/A converter, current steering D/A, calibration for improved performance, delta-sigma D/A-converters.

**Lecture notes**

- Slides are available online under https://lis-students.ee.ethz.ch/lectures/analog-to-digital-converters/

**Prerequisites / notice**

- It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
Abstract

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes

Available on the course Moodle platform.

Prerequisites / notice

Sufficient mathematical maturity, in particular in linear algebra, analysis.

Competencies

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227-0377-10L Physics of Failure and Reliability of Electronic Devices and Systems

Abstract

Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective

Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content

Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Lecture notes

Comprehensive copy of transparencies

Literature


227-0417-00L Information Theory I

Abstract

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective

The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel-source-channel separation theorem, feedback capacity

Literature

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

227-0579-00L Hardware Security

Abstract

This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures and implementing some of these advanced attacks.

Objective

By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:

- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Literature

Slides, relevant literature and manuals will be made available during the course.

Prerequisites / notice

Experience with Linux, low-level systems programming and computer architecture.

Competencies

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<td>Self-direction and Self-management</td>
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227-0654-00L Carbon-based Nanoelectronics

Abstract

This course explores the exciting realm of carbon-based nanoelectronics, where the remarkable quantum properties of materials like graphene, carbon nanotubes, graphene nanoribbons, and single molecules are used for building electronic devices.
The objective of this course is to understand how the electronic properties of carbon-based materials can be exploited for fabricating quantum devices. We will delve into both the theoretical and experimental aspects, discussing how these materials’ unique properties can be translated into device functionality.

On the theoretical side, we'll cover how the chemical structure of the material and its dimensionality, ranging from 0D to 2D, affects the electronic properties. We'll also discuss how charge carriers flow through the devices and what charge transport mechanisms are at play.

On the experimental side, we'll cover how such devices are fabricated, including how the materials are synthesized. We'll also discuss how to characterize the devices and assess their performance.

The course will cover the following carbon-based materials:
- Single-molecule
- Graphene (single layer, bilayer, twisted bilayer)
- Graphene nanoribbons
- Carbon nanotubes

For each material, we will discuss:
- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

The course also includes a presentation by each student in which a related scientific publication is discussed. This presentation is compulsory and accounts for 30% of the grade.

Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

In addition to the slides, the following supplementary books can be recommended:

A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

227-0671-00L Nanodevices and Circuits for the Beyond-Moore Era

Objective
Big Data, AI, and the Internet of Things demand new hardware which overcomes the limitations of von Neumann architectures. The lecture gives an insight into how the fundamental physics and the resulting complex functionalities of nanodevices and circuits offer viable alternatives. Their increased computational power and energy efficiency are demonstrated through neuromorphic computing applications.

The students will gain a firm understanding in the theory and pioneering experiments of electronic and heat transport at atomic- to nanometer length-scales. Advanced device functionalities enabled by recently discovered material systems will be covered. The students will learn how to exploit such phenomena for designing nanodevices and circuits to energy-efficiently implement neuromorphic algorithms for a sustainable future of information technologies.

Lecture notes
The presentation slides and further material will be provided every week.

Prerequisites / notice
Basic knowledge of solid state physics and semiconductors.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

227-0689-00L System Identification

Objective
Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data. To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models. Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Literature

Prerequisites / notice
Control systems (227-0216-00L) or equivalent.

Additional papers will be available via the course Moodle.

227-0955-00L Seminar in Electromagnetics, Photonics and Terahertz

Abstract
Selected topics of the current research activities at the IEF and closely related institutions are discussed.
Objective
Have an overview on the research activities of the IEF institute.

252-0535-00L Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

327-2210-00L Thin Films Technology - From Fundamentals to Oxide Electronics

Abstract
Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal.

We will give an introduction to thin films deposition techniques and applications with a focus on the growth of multifunctional oxide thin films.

Objective
In this course students will obtain an overarching view on thin film deposition techniques with a focus on epitaxial deposition processes. The main learning objectives are:

- Identification of most relevant deposition technique for a given application.
- Understanding of growth mechanism and growth modes.
- Understanding strategies for engineering the functionalities of the films using the deposition process.
- Selection of the most appropriate characterization technique.
- Understanding device concepts and fundamental limits in the technology relevant ultra-thin limit.
- Assessing the relevance of scientific literature dealing with complex oxide thin films.
Content  A lab visit visit will be organized and students will participate to the design of thin films with atomic precision.

General description of the leading deposition routes including physical and chemical vapor deposition techniques (PVD and CVD) as well as so called "wet techniques" (e.g. spin coating and spray pyrolysis).

Growth modes and processes.

Part of the course discusses vacuum technologies.

Fundamental characterization techniques for application-relevant thin films as well as state of the art approaches for in situ and ex-situ determination of the structural, chemical and ferroic (ferromagnetic and ferroelectric) properties of films: (XRD for thin films, RHEED, EDX, scanning probe microscopy techniques, laser-optical characterization and many more)

Epitaxy for the advanced design and characterization of high quality thin films for energy efficient oxide electronics.

Types of ferroic order, multiferroics, multifunctional oxide materials, epitaxial strain related effects, oxide thin film based devices and examples.

Regular discussions on preselected scientific literature and mini-seminars will be organized.

Competencies

Subject-specific Competencies

- Concepts and Theories: fostered
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: fostered
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies

- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

401-3055-64L  Algebraic Methods in Combinatorics  

Abstract  Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective  The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content  One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes  Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice  Students are expected to have a mathematical background and should be able to write rigorous proofs.

401-5680-00L  Foundations of Data Science Seminar  

Abstract  Research colloquium

402-0475-00L  Terahertz Science and Applications  

Abstract  The Terahertz (THz) range (0.1 – 10 THz), lies between the infrared and microwave spectral regions and has become accessible in the past few years. This new capability has had great impact in scientific research, and has led to technological advances and to the development of a variety of applications and devices. This course provides an introduction to THz science, technology and applications.

The goal of this course is to enable students to determine whether a THz solution can be applied to a particular scientific or technological problem. Armed with the fundamentals of THz science and of current THz technologies, covered in this introductory course, students will be able to weigh the capabilities, advantages and limitations of THz tools to address topics ranging from phonons in solid state systems and molecular vibrations in solutions to medical imaging and wireless communications.
Ethics in Technology, fostered

Should we use this technology or not? What are the ethical opportunities and risks of this technological application? Should we always foster communication? This course considers the correlation between ethics and technologies. The relationship of ethics and technologies will be explored as

Ethics and Scientific Integrity for Doctoral Students, fostered

In times of fast technological progress and rapid technology-based innovation, being able to distinguish on ethical grounds what is assessed

Subject-specific Competencies
- Concepts and Theories (assessed)
- Techniques and Technologies (assessed)

Method-specific Competencies
- Analytical Competencies (assessed)
- Decision-making (fostered)
- Problem-solving (assessed)

Social Competencies
- Communication (assessed)
- Cooperation and Teamwork (fostered)
- Leadership and Responsibility (fostered)

Personal Competencies
- Adaptability and Flexibility (assessed)
- Creative Thinking (assessed)
- Critical Thinking (assessed)
- Integrity and Work Ethics (fostered)
- Self-awareness and Self-reflection (fostered)
- Self-direction and Self-management (fostered)

Transferable Skills

During the doctoral studies, at least 1 CP ECTS must be acquired in the field of ethics / good scientific practice. See also https://www.ethicsrp.ethz.ch/courses.

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<td>Ethics in Technology</td>
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<tr>
<td>Abstract</td>
<td>Should we use this technology or not? What are the ethical opportunities and risks of this technological application? Should we always pursue all that is technically possible? What is ethics? How do ethics and technologies relate to each other? Does ethics hinder technological progress? How can ethics foster innovation? Which ethical theory should we apply in a global research-context? The course fosters this in times of fast technological progress and rapid technology-based innovation, being able to distinguish on ethical grounds what is technically feasible from all that is technically possible proves to be essential for a humane and sustainable future for humanity and for the planet. The aim of this introductory course is to introduce the ethics of technology by discovering different ethical theories and models while applying them to concrete technological innovations.</td>
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Literature


Sven Nyholm (2023). This is Technology Ethics: An Introduction, Hoboken: Wiley.


851-0178-00L | Ethics and Scientific Integrity for Doctoral Students | W    | 1    | 2U    | G. Achermann |
| Abstract | This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop. |
| Objective | Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers. |
This seminar aims to understand better what creativity and creative thinking is by looking at the history of the creativity dispositive we are.

### Part I: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

### Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

### Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

### Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

### Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

### Part II
The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

#### Competencies

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### Prerequisites / notice
For doctoral students only.

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II).

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

- **Transferable Skills Course I (1-3 days)**
  - Only for doctoral students.
  - Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
  - Abstract: Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
  - Objective: Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

- **Transferable Skills Course II (1-3 days)**
  - Only for doctoral students.
  - Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
  - Abstract: Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
  - Objective: Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

- **Member of Executive Board (min 1 year)**
  - Only for doctoral students.
  - Course offers in humanities, political and social sciences (Science in Perspective)
  - Educational Science for Teaching Diploma and TC
  - Language Courses ETH/UZH: see Science in Perspective

### Notice
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Course offers in humanities, political and social sciences (Science in Perspective)**

**Educational Science for Teaching Diploma and TC**

**Language Courses ETH/UZH: see Science in Perspective**

**Only for doctoral students.**
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### Abstract

Active participation in the presidium or executive board of a university group for at least 1 year.

### Objective

Active participation in the presidium or executive board of a university group for at least 1 year.

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**Integration into Scientific Community**

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Abstract
Participation in summer or winter schools with a minimum duration of 1 week.

Objective
Participation in summer or winter schools with a minimum duration of 1 week.

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<tr>
<th>Code</th>
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Doctorate Information Technology and Electrical Engineering - Key for Type

| Z  | Courses outside the curriculum                      | W+ | Eligible for credits and recommended |
| Dr | Suitable for doctorate                              | W  | Eligible for credits                |
| O  | Compulsory                                          | E- | Recommended, not eligible for credits |

Key for Hours

| V  | lecture                                           | P  | practical/laboratory course       |
| G  | lecture with exercise                             | A  | independent project               |
| U  | exercise                                         | D  | diploma thesis                    |
| S  | seminar                                          | R  | revision course / private study    |
| K  | colloquium                                        |    |                                   |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Subject Specialisation

## Doctorate Management, Technology, and Economics


### Management

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>364-1110-00L</td>
<td>Foundations of Innovation Studies</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Brusoni</td>
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**Abstract**  
This course will introduce some of the major theoretical threads and controversies in the broad field of innovation. During the first part of the course, the emphasis will be on the evolution of innovation studies. The final part of the course will focus on one of the directions in which those studies have evolved: the field of managerial cognition.

**Objective**  
Students will learn about various perspectives, examine different methodologies, explore some original empirical research, make connections between theory and empirical research, and practice reviewing and identifying insights in research.

1) Be able to display some knowledge on a few major theoretical streams in the area.
2) Be familiar with the methods, issues and current gaps in the area.
3) Have practiced skills in finding insight and reviewing the literature.
4) Have practiced skills in defining research problems and proposing empirical research in this area.

**Competencies**

- **Subject-specific Competencies**  
  - Concepts and Theories assessed
  - Analytical Competencies assessed
  - Problem-solving assessed

- **Method-specific Competencies**
  - Communication assessed
  - Cooperation and Teamwork assessed
  - Leadership and Responsibility fostered
  - Self-presentation and Social Influence assessed
  - Sensitivity to Diversity fostered

- **Social Competencies**
  - Negotiation fostered

- **Personal Competencies**
  - Adaptability and Flexibility fostered
  - Creative Thinking fostered
  - Critical Thinking assessed
  - Integrity and Work Ethics assessed
  - Self-awareness and Self-reflection assessed

### Hacking for Sciences - An Applied Guide to Programming with Data

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<td>Hacking for Sciences - An Applied Guide to Programming with Data</td>
<td>W</td>
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<td>2V</td>
<td>M. Bannert</td>
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**Abstract**  
The vast majority of data has been created within the last decade. As a result, more and more fields of research start to consider and embrace programming to process and analyse data. This course teaches applied programming with data and aims to leverage the open source tech stack to deal with this new wealth and complexity of data.

**Objective**  
The idea behind Hacking for Science is build a solid understanding of core technologies and concepts to help researchers develop a data processing strategy and increase your possibilities when working with data. The course approach is to single out those concepts stemming from software development that are easy to adopt and useful to non-computer scientists. The course has three major learning objectives:

- Understand the role of focal components in a data science tech toolbox.
- Learn how technologies like R, Python, Git Version Control, docker or Cloud Computing could play together in your research project.
- Learn how to communicate with SQL databases. Learn how to consume data from different sources using machine to machine communication interfaces (APIs) such as the OpenStreetMap geocoding API / Routing Engine or the KOF data API for macroeconomic time series.

**Non-Goals:**

- Hacking for Science is not a Statistics, Econometrics or Machine Learning course. Though experience in these fields will help inasmuch that students will have an easier time to motivate investing in programming and to come up with their own application examples, profound methodological knowledge is not a prerequisite.
- Hacking for Science teaches how to use git version control to collaborate professionally, make your research reproducible and your code base persistent.
- Applied data sourcing and data transformation
- Learn how to use git version control to collaborate professionally, make your research reproducible and your code base persistent.
- Application of software like R and Python to container technology such as docker.

**Content**

Hacking for Science is a guide to programming with data. It is tailored to the field of a field in which scholars' typical curricula do not contain a strong programming component. Yet this course argues that what the open source community calls a 'software carpentry' level is totally within reach for a quantitative social scientist and well worth the investment: being able to code leverages field specific expertise and fosters interdisciplinary collaboration, as source code continues to become an important communication channel.

The course contains three blocks that are mostly based on the three learning objectives presented above. Hacking for Science explicitly plans to spread its three blocks over 1-2 months to give students the ability to work on applied examples in between sessions in order to get most out of the subsequent session.

The first block demonstrates the components of a modern data science tech stack, classifies technologies and gives a big picture overview: from languages such as R and Python to container technology such as docker. The second block focuses on git version control, the de facto industry standard to manage source code. Version control is not only crucial to knowledge management and reproducible research, but it is also the backbone of collaboration in distributed teams. The third and final block focuses on data themselves and teaches how to obtain data through machine to machine communication. Furthermore, the third block discusses data management in a research project.

**Lecture notes**

A free and open online book (made with quarto) is available from https://rse-book.github.io/. The book/script will be continuously updated during the course to account for questions and participants' questions.

All course materials including, slides, resources and source code will be made available through the course Website: https://rseed.ch/h4sci.html
Prerequisites / notice

Basic experience with either R or Python, e.g., a stats course that was taught using R.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Innovation in Digital Space

364-0553-00L

W 1 credit 1G

G. von Krogh, to be announced

Abstract
The purpose of this course is to review and discuss issues in current theory and research relevant to innovation in the digital space.

Objective
Through in-depth analysis of published work, doctoral candidates will identify and appraise theoretical and empirical studies, formulate research questions, and improve the positioning of their own research within the academic debate.

Content
The Internet has a twofold impact on the way individuals and firms innovate. First, firms increasingly draw on digital technology to access and capture innovation-relevant knowledge in their environment. Second, individuals, firms, and other organizations extensively utilize the Internet to create, diffuse, and commercialize new digital products and services. During the past decade, theory and research on innovation in the digital space has flourished and generated extensive insights of relevance to both academia and management practice. This has brought us better understanding of working models, and some fundamental reasons for innovation success or failure. A host of new models and research designs have been created to explore the innovation in the digital space, but these have also brought out many open research questions. We will review some of the existing streams of work, and in the process explore a new research agenda.

Format:
The course is organized in one block of 2 days. The course is a combination of pre-readings, presentations by faculty and students, and discussions. The students prepare presentations of papers in order to facilitate analysis and discussion.
Subject-specific Competencies

In the first class, current understanding of the marketing literature and marketing thought is discussed. Concepts and Theories 1 credit

The course is taught by Florian Wangenheim (ETHZ). Organizational behavior concerns the study of individual and group-level processes in organizations like creativity, motivation, and leadership. In this PhD course, an overview of major concepts and research insights in organizational behavior is provided. The participants are encouraged to discuss their own work situation as PhD students in relation to the OB insights covered in the course.

The objectives of the course are:
- to provide an overview of OB research
- to discuss major research streams in OB
- to enable students to reflect their own work situation based on concepts used in OB.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management fostered

Organizational behavior concerns the study of individual and group-level processes in organizations like creativity, motivation, and leadership. In this PhD course, an overview of major concepts and research insights in organizational behavior is provided. The participants are encouraged to discuss their own work situation as PhD students in relation to the OB insights covered in the course.

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Project Management assessed

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Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management fostered

Open source (OS) as innovation model

Lerner, J., & Tirole, J. (2002). Some Simple Economics of Open Source. JIE

Cooperation in OS communities


Organizational Behavior


Governance & Leadership


Motivation to collaborate


Abstract

Marketing Theory

The course is taught by Florian Wangenheim (ETHZ). It focuses on the theoretical foundations of marketing and marketing research. The purpose of the course is to confront students with current theoretical thinking in marketing, and currently used theories for understanding and explaining buyer and customer behavior in response to marketing action.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management fostered

Organizational Behavior

Does not take place this semester.

Abstract

Organizational behavior concerns the study of individual and group-level processes in organizations like creativity, motivation, and leadership. In this PhD course, an overview of major concepts and research insights in organizational behavior is provided. The participants are encouraged to discuss their own work situation as PhD students in relation to the OB insights covered in the course.

Competencies

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Cooperation and Teamwork fostered
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Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management fostered

Methods in Management Research

Does not take place this semester.

Abstract

This course covers available methodologies and research design in management research, measurement and validity issues, and a broad overview of the main quantitative and qualitative methods. Students will reflect on the fit between research question and research design in their own research field.

Abstract

The course is taught by Florian Wangenheim (ETHZ). It focuses on the theoretical foundations of marketing and marketing research. The purpose of the course is to confront students with current theoretical thinking in marketing, and currently used theories for understanding and explaining buyer and customer behavior in response to marketing action.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management fostered

Methods in Management Research

Does not take place this semester.

Abstract

This course covers available methodologies and research design in management research, measurement and validity issues, and a broad overview of the main quantitative and qualitative methods. Students will reflect on the fit between research question and research design in their own research field.
The course aims to support students in:

- knowing basic quantitative and qualitative research methods
- understanding what data each method needs and what outcomes it can provide, as well as its advantages and disadvantages
- understanding how to link a research question to an appropriate research design and method
- acquiring a basic understanding of how each method works (e.g., which software to use)
- having an idea of how to apply these methods to one's own research
- having a group of peers to share ideas and feedback with

This course covers basic methodological topics relevant to research in the management field, including available methodologies (inductive, deductive) and research design (e.g., interviews, field survey, lab experiment, secondary data), the definition and measurement of constructs, validity, the choice of data collection and data analysis methods. A broad overview of the main quantitative (ANOVA, regression, path analysis, SEM, multilevel models, growth models) and qualitative methods (thematic analysis, grounded theory) currently used in management research will also be provided, together with a brief analysis of the advantages and disadvantages of each method.

Topics related to research design, including pre-registration, power analysis, and data management, as well as level of analysis and temporal issues (in particular related to data collection) can also be discussed, depending on the interest of the class. Finally, the course will cover fit between research question, research design, and methods of data analysis.

**Literature**
(Refer to Syllabus and Moodle)

**Prerequisites / notice**

Students should: (1) Be able to read and understand academic papers, including both empirical papers and method papers, to facilitate and actively participate to the class discussions; (2) Download SPSS and R + R Studio before the course to be able to conduct hands-on exercises in class; (3) complete a short survey that the instructor will share before the course, with he goal of optimising course organisation.

**Competencies**

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<td>Self-direction and Self-management</td>
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**364-1154-00L  Technological Innovations and Sustainability Transitions**  
**W Dr 3 credits 2S J. Markard**

**Abstract**

Intro to sustainability transitions: fundamental socio-technical changes in sectors such as energy or transport with the intention to improve sustainability. We discuss past and contemporary transition examples (e.g. net-zero energy transition), key concepts & frameworks and challenges for research and policy making.

**Objective**

The course provides a better understanding of innovation, transition and sustainability challenges. After completing this course, students will
- understand the particularities and complexities of selected empirical examples of sustainability transitions,
- be familiar with key concepts and frameworks of research in sustainability transitions and innovation studies,
- know the relevant literature on transition studies and adjacent fields (corporate sustainability, policy analysis) and
- be able to apply the new knowledge, e.g. to design a research project in the field.

**Content**

Societies are confronted with major sustainability challenges such as climate change, resource depletion, water pollution, or loss of biodiversity. To address these challenges, we need fundamental changes in how we produce and consume things. We need to transform business models, industries, technologies, policies, lifestyles and habits. Sustainability transitions is a new and rapidly growing field of research addressing major socio-technical changes, typically at the sectoral level. Sustainability transitions research seeks to analyze and understand the multi-dimensional nature of innovation and decline, and to provide tools for researchers and decision makers to navigate transitions. Widely known cases include the ongoing energy transition (with renewables replacing fossil and nuclear fuels) or the transition toward electric mobility. Also in other sectors, more sustainable niches are emerging (non-meat alternatives, bioplastic, responsible finance etc.)

In the course, we will familiarize ourselves with key concepts and topics including 'classic' innovation theory, innovation systems, incumbent organizations vs newcomers, the multi-level perspective, politics of transitions and sustainability transition policies. We will read, present and discuss peer-reviewed literature and we will develop and discuss ideas for potential research projects.

**Format:**

The course will consist of 2*90min sessions on Monday afternoons. There is a combination of preparatory reading, presentations by faculty and students, short papers, and discussions.

**Dates:** Feb 20, 27, March 13, 20, 27, April 3, 24, May 8, 15, 22.

**Attendance is required in all sessions.**

**Pls reserve Mondays, 2-5pm. Some Mondays might be free, some meetings will be shorter (also depending on enrolment).**

**Compétences**

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<td>Self-direction and Self-management</td>
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**Economics**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tbody>
<tr>
<td>364-1025-00L</td>
<td>Advanced Microeconomics</td>
<td>E-</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Bommier</td>
</tr>
</tbody>
</table>

**Abstract**

The objective of the course is to provide students with advanced knowledge in some area of micro economic theory. The course will focus on 1) Individual behavior 2) Collective behavior 3) Choice under uncertainty 4) Intertemporal choice.
**Objective**
The aim is to give to the students the opportunity to review the key results in rational individual behavior, collective models, choice under uncertainty, intertemporal choice, as well as to get some insights on more recent advances in those areas. The course is therefore designed for students who have some interest for research in economics.

**Content**
The following topics will be addressed:
2) Collective models. Cooperative and non-cooperative models of household behavior.
3) Choice under uncertainty. The foundations of expected utility theory. Some insights on other approaches to choice under uncertainty.
3) Intertemporal choice. Dynamic model. Life cycle theory.

**Literature**
The course will be based on some chapters of the books "Advanced Microeconomic Theory" by Jehle and Reny (2011) and "Microeconomic Theory", by Mas-Colell, Whinston and Green (1995), as well as research articles for the most advanced parts.

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**364-1179-00L**

**Calibration in Macroeconomics**

**Abstract**

Macroeconomic models allow us to perform policy counterfactuals related to inequality, monetary policy, and trade. But to believe our predictions, the models’ parameters must be reasonable. Calibration is the process of choosing parameters (usually related to technology and preferences). This course explores common approaches with applications to inequality, trade, finance, and monetary policy.

**Objective**

Using examples from both classic and frontier papers in quantitative macroeconomics, this course teaches students popular approaches to calibrating models and evaluating model fit. While the emphasis is on calibration methodology, students will also learn about a variety of model solution algorithms, key datasets, standard parameter values, and the contributions/takeaways of the various papers. After taking this course, students will be able to:
- understand and implement the main approaches to calibration
- assess the plausibility and fit of calibrations in new papers or their own research
- integrate standard functional forms and parameter values into their research
- gather and analyze key datasets used in calibration
- understand the basics of a variety of solution algorithms for equilibrium models

Additionally, the course gives students a sense of the frontier of research in some of the fields covered.

**Content**

The course is designed for PhD students in economics, finance, and related fields, especially those who wish to use quantitative macroeconomic models for research or policy. Enrolling students should have experience with graduate-level economic theory and be able to code in one of the programming languages commonly used in macroeconomics (e.g., Matlab, Python, Julia, Fortran, etc.).

The purpose of the course is to show students how calibration is and has been used in quantitative macroeconomics. The predictions and implications of macroeconomic models – the costs of trade barriers, the causes of changes in inequality, the effects of fiscal and monetary policy shocks, and the consequences of sovereign default for example – depend on the underlying parameters. Typical parameters include consumer risk aversion and patience, firm and consumer elasticities of substitution, the variance and persistence of shocks to firms and consumers, and credit constraints. To believe the welfare implications, counterfactuals, or forecasts of our models, the parameters must be set to “reasonable” values. Calibration is the process of choosing reasonable parameters using, for example, previous research, estimates from microeconomic data, or the comparison of model moments with empirical counterparts.

Calibration is an essential tool in macroeconomics. It is employed in a large fraction of the academic literature as well as in many influential policy analyses. The course is directed towards researchers interested in the frontier of macroeconomic theory, but it is also relevant for anyone working on policy-related theoretical models in public finance, trade, and international finance.

The instructor will prepare and present lecture slides, but class discussion is strongly encouraged. Students are expected to read the papers assigned for each week. Assessment is based on a final project: each student must replicate the main result of a paper from the class or another paper approved by the instructor.

**Literature**
The course is framed around papers that discuss or employ calibration, likely including:

**Prerequisites / notice**

Knowledge of graduate-level economic theory.

**Competencies**

- Subject-specific Competencies: Concepts and Theories assessed
- Techniques and Technologies assessed
- Analytical Competencies fostered
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving fostered
- Project Management fostered

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**364-0531-00L**

**CER-ETH Research Seminar**

**Abstract**

Research Seminar of Center of Economic Research CER-ETH

**Objective**

Understanding cutting-edge results of current research in the fields of the CER-ETH Professors.

**Content**


**Prerequisites / notice**

Bitte spezielle Ankündigungen beachten.

**Competencies**

- Subject-specific Competencies: Concepts and Theories fostered
- Techniques and Technologies fostered
- Analytical Competencies fostered

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**364-0556-00L**

**Doctoral Workshop: Astute Modelling**

**Abstract**

In this workshop, ongoing research is presented and the criteria and guidelines for astute modelling of economic, political, and social situations are discussed.

**Objective**

We will learn how to craft models, how to present our own research and improve our analytical skills.
Prerequisites / notice

Students are expected to attend the doctoral course "Macroeconomic Dynamics" before registering for this workshop.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Technologies and Techniques</th>
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<tr>
<td>Concept and Theory</td>
<td>Technique</td>
<td>Method</td>
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Method-specific Competencies

fostered

Prerequisites / notice

Students who have successfully completed the course "Dynamic Macroeconomics" (364-0559-00L) or "Economics of Innovation and Growth" (363-0562-01L) cannot register for this course.

363-1136-00L Dynamic Macroeconomics, Innovation and Growth

| W | 3 credits | 2V | S. Zezner, H. Gersbach |

Abstract

Introducing dynamic models and workhorses in macroeconomics, understanding the role of innovation and institutions for economic development and discussing policies to foster innovation and economic growth.

Objective

After the course, students will be familiar with dynamic general equilibrium theory and the basic workhorse models in macroeconomics. Participants will be able to apply the frameworks to interesting issues, such as innovation and growth. Moreover, students will understand how the world has developed over the last centuries and the proximate and fundamental causes of innovation and economic growth. Students will understand and apply the basic models of economic growth and will be able to identify policies to foster innovation and growth and to reduce the large wealth differences in the world. Finally, they will get an idea how digitization and artificial intelligence might drive economic growth.

Content

1. Introduction

2. The Solow Model

3. The Neoclassical Growth Model (with Mathematical Background)

4. Technological Progress and how the World has developed

5. Innovations and Growth (New Growth Theory)

6. Growth Policies and Fundamental Causes for Growth

7. Digitization and Artificial Intelligence

Literature


14. Current Literature on Digitization and Artificial Intelligence

Prerequisites / notice

Students who have successfully completed the course "Dynamic Macroeconomics" (364-0559-00L) or "Economics of Innovation and Growth" (363-0562-01L) cannot register for this course.

364-1168-00L Economics of Inequality

| W | 3 credits | 2V | I. Martinez |

Abstract

We discuss research on inequality in different areas of economics. Possible topics include distributional national accounts, heterogeneous returns, inheritances, intergenerational mobility, gender inequality in the labor market (topics will also be decided upon depending on the students' interests). Students will present a paper and critically comment on it (as if they would referee the paper).

Objective

After the course, participants will have a solid understanding of the current state of research on inequality in different fields in economics and, starting from there, will be able to develop their own research ideas. They will further learn how to critically assess and referee a paper, as it is common practice during the referee process, and they will practice their presentation skills and give feedback to each other. The students will therefore also acquire competences for conferences and participation in the scientific discourse.
The course focuses on important factors that drive the innovation performance of firms, like innovation capabilities, the use of digital
The course provides students with the basic skills to understand and assess empirically the technological activities of firms and the

The target group of this course are PhD students who are interested in writing a paper related to economic inequality. Advanced Master
students who are interested in taking the course, especially those who plan to pursue a PhD in Economics, are welcome, too. The topic is
intentionally kept broad to leave room for individual research interests and cover different areas. This will allow students to get to know the
current state of research in different but related areas, and help them develop their own research question.

By critically examining the literature, students will also learn what makes a well-written paper. By presenting papers, students will further
train their presentation skills, and we will take time to give feedback in class on the presentations, too. Oral and written presentation of
research are both integral parts of a successful academic career. In the written assignment, finally, students will write a referee report or a
research proposal, starting from a paper we discussed in the course.

The course will start with an introduction into the topic and an overview of inequality research in economics. Inequality has become a buzz-
word in many paper titles and abstracts, but different areas of economics have sometimes very different approaches to this popular topic.
The main part of the course will consist of reading and presenting papers that belong to different areas of economics, including
Macroeconomics, Public Economics, and Microeconomics / Labour Economics.

Below you find the *suggestive* syllabus for this course. I will provide a list of papers in each of the six blocks at the beginning of the
semester, and students will choose a paper to present during the semester (suggestions to present a paper that is not on the list are
welcome). Students are required to read all papers discussed in the course and active participation is expected. At the end of the semester,
they will write a referee report with possible suggestions for future research or develop a research proposal. The written assignment is due
by January 24, 2024.

Topics (suggestive)
Aggregate trends in income and wealth inequality
- Top income and wealth shares
- Distributional national accounts DINA
- Wealth income ratios

Measurement of top wealth and its difficulties
- Capitalization and heterogeneous returns
- Tax data and tax evasion
- Alternative data and its limitations

Inheritances
- Their role for wealth inequality
- Optimal taxation of inheritances

Intergenerational mobility
- Measurement
- Exogenous variation and causal identification

Gender Inequality in the labour market
- Gender wage gap
- Child penalties

Pandemics and their effects on inequalities
- Covid-19
- 1918 Influenza Pandemic ("Spanish Flu")
- The plague

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
Analytical Competencies

Social Competencies
Communication

Personal Competencies
Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Empirical Innovation Economics

Abstract
The course focuses on important factors that drive the innovation performance of firms, like innovation capabilities, the use of digital
technologies, environmental and innovation policy and it shows how innovation activities relate to firm performance and to the technological
dynamic of industries. We also discuss the implications of the findings for effective economic policy-making.

Objective
The course provides students with the basic skills to understand and assess empirically the technological activities of firms and the
technological dynamics of industries. In addition, the aim is to promote the understanding of the essential criteria for innovation policy-
making.

Content
The course consists of two parts. Part I provides an introduction into important topics in the field of the economics of innovation. Part II
consists of empirical exercises based on various firm-level data sets, e.g., the KOF Innovation data, data about the digitization of firms,
data about environmentally friendly innovations, or patent data. In part I, we will learn about ... a) market conditions that encourage firms to
invest in R&D (Research and Development) and develop new products and processes. ... b) the role of competition and market structure
for the R&D activities of companies. ... c) how digital and environmentally friendly technologies diffuse among firms. ... d) how the R&D
activities of firms are affected by economic crises and how firms finance their R&D activities. ... e) how we can measure the returns to R&D
activities. ... f) how environmental policies and innovation policies affect the technological activities of a firm. In part II we will use the KOF
Innovation Survey data, patent data, data on digitization of firms, or other longitudinal data sources, to investigate empirically the
technological activities of firms in relation to the topics introduced in part I.

Lecture notes
Will be provided in the course and in the e-learning environment: https://moodle-app2.let.ethz.ch/course/view.php?id=15120

Literature
Literature will be presented in the course. For an introduction into the economics of innovation see G.M. Peter Swann, The Economics of
For an overview of empirical innovation studies see W.M. Cohen (2010): Fifty Years of Empirical Studies of Innovation Activities and
Prerequisites / notice

Course is directed to advanced Master-Students and PhD Students with an interest in empirical studies.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management assessed

364-1015-00L KOF-ETH-UZH International Economic Policy Seminar (University of Zurich)
W 2 credits 2S P. Egger, J.-E. Sturm, University lecturers

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
In this seminar series, which is held jointly with Prof. Dr. Woltek and Prof. Dr. Hoffman from the University of Zurich, distinguished international researchers present their current research related to international economic policy. The participating doctoral students are expected to attend the presentations (bi-weekly). Moreover, a critical review has to be prepared for 1 of the papers presented

Objective
On the one hand, participating students are exposed to research at the frontier of international economic policy research. On the other hand, skills such as critical thinking and preparing reviews are learned.

364-0581-00L Microeconomics Seminar (ETH/UZH)
E- 0 credits 2S H. Gersbach

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
Research Seminar research papers of leading researchers in Microeconomics are presented and discussed

Objective
Research Seminar research papers of leading researchers in Microeconomics are presented and discussed

Content
Invited Speakers present current research in Microeconomics

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed

364-0585-01L PhD Course: Applied Econometrics
W 2 credits 2V P. Egger

Abstract
In this course, we will address three blocs of selected problems: (i) estimation of fixed and random effects panel data models for single equations and systems of equations; (ii) estimation of models with endogenous treatment effects or sample selection; (iii) estimation of models with interdependent data (so-called spatial models).

Objective
The main agenda of this course is to familiarize students with the estimation of econometric problems with three alternative types of problems: (i) estimation of fixed and random effects panel data models for single equations and systems of equations; (ii) estimation of models with endogenous treatment effects or sample selection; (iii) estimation of models with interdependent data (so-called spatial models). Students will be able to program estimation routines for such problems in STATA and apply them to data-sets. They will be given a data-set and will have to work out empirical problems in the context of a term paper.

Lecture notes


For spatial econometrics:
I will mostly use papers.

I will prepare a script (based on slides), covering all topics.

364-1090-00L Research Seminar in Contract Theory, Banking and Money (University of Zurich)
W 3 credits 2S H. Gersbach, University lecturers

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 03SMDOEC1096

Content
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered

Lecture notes


For spatial econometrics:
I will mostly use papers.

I will prepare a script (based on slides), covering all topics.
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

### Lecturers

**H. Schernberg**

This course is a mixture between a seminar primarily for PhD and postdoc students and a colloquium involving invited speakers. It consists of presentations and subsequent discussions in the area of modeling complex socio-economic systems and crises. Students and other guests are welcome.

#### Objective

Participants should learn to get an overview of the state of the art in the field, to present it in a well understandable way to an interdisciplinary scientific audience, to develop novel mathematical models for open problems, to analyze them with computers, and to defend their results in response to critical questions. In essence, participants should improve their scientific skills and learn to work scientifically on an internationally competitive level.

#### Content

This course is a mixture between a seminar primarily for PhD and postdoc students and a colloquium involving invited speakers. It consists of presentations and subsequent discussions in the area of modeling complex socio-economic systems and crises. For details of the program see the webpage of the colloquium. Students and other guests are welcome.

#### Lecture notes

There is no script, but a short protocol of the sessions will be sent to all participants who have participated in a particular session. Transparencies of the presentations may be put on the course webpage.

#### Literature

Literature will be provided by the speakers in their respective presentations.

#### Prerequisites / notice

Participants should have relatively good mathematical skills and some experience of how scientific work is performed.

#### Abstract

This course is a mixture between a seminar primarily for PhD and postdoc students and a colloquium involving invited speakers. It consists of presentations and subsequent discussions in the area of modeling complex socio-economic systems and crises. Students and other guests are welcome.

#### Additional Courses

<table>
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<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>364-1064-00L</td>
<td>Doctoral Retreat - Inaugural Workshop and Seminar on Ethics and Scientific Integrity</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>A. Bommer</td>
</tr>
</tbody>
</table>

#### Abstract

This course is geared towards first and second-year doctoral candidates of MTEC. It is held as in a workshop style. Students attending this seminar will benefit from interdisciplinary discussions and insights into current and future work in business and economics research.

#### Objective

The purpose of this course is to
- introduce doctoral candidates to the world of economics, management and systems research at MTEC
- make doctoral candidates aware of silo-thinking in the specific sub-disciplines and encourage them to go beyond those silos
- discuss current issues with regard to substantive, methodological and theoretical domains of research in the respective fields
- sensitize doctoral candidates to ethical issues that may occur during their doctorate.
- familiarize doctoral candidates with resources that can assist them with ethical decision-making

#### Content

This course is geared towards first and second-year doctoral candidates of MTEC. It is held as in a workshop style. Doctoral candidates attending this seminar will benefit from interdisciplinary discussions and insights into current and future work in business and economics research. The second, face-to-face part of the Ethic course focuses on discipline-specific aspects and takes place on the 2nd day of the retreat. It provides an interactive learning environment. Doctoral candidates get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral colleagues.

#### Transferable Skills

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<tbody>
<tr>
<td>900-0100-DRL</td>
<td>Transferable Skills Course I (1-3 days)</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>Lecturers</td>
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</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### Abstract

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

#### Objective

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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<tr>
<td>900-0101-DRL</td>
<td>Transferable Skills Course II (1-3 days)</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
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</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

## Additional Resources

- [Mind the enrolment deadlines at UZH:](https://www.uzh.ch/cmsssl/en/studies/application/deadline.html)
- [Techniques and Technologies](#)
- [Abstract](#)
- [Objective](#)
- [Competencies](#)
- [Method-specific Competencies](#)
- [Subject-specific Competencies](#)
- [Concepts and Theories](#)
- [Methods and Technologies](#)
- [Additional Courses](#)
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<thead>
<tr>
<th>Session</th>
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<td>900-0102-DRL</td>
<td>Transferable Skills Course III (1-3 days)</td>
<td>W</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL  Transferable Skills Course II (1 week, with Poster or Talk)
Only for doctoral students.

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Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL  Transferable Skills Course III (1 week, with Poster or Talk)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL  Participation in Commission I (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL  Participation in Commission II (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL  Member of Executive Board (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Active participation in the presidium or executive board of a university group for at least 1 year.

Objective Active participation in the presidium or executive board of a university group for at least 1 year.

Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>2K</td>
<td>Lecturers</td>
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Abstract Participation in summer or winter schools with a maximum duration of 3 days.

Objective Participation in summer or winter schools with a maximum duration of 3 days.

900-0151-DRL  Summer School II (1-3 days)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a maximum duration of 3 days.

Objective Participation in summer or winter schools with a maximum duration of 3 days.

900-0152-DRL  Summer School III (1-3 days)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a maximum duration of 3 days.

Objective Participation in summer or winter schools with a maximum duration of 3 days.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Participation in summer or winter schools with a maximum duration of 3 days.

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<tr>
<th>Course Code</th>
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<th>Duration</th>
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<th>Lecturers</th>
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<td>Summer School I (1-3 days, with Poster or Talk)</td>
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<td>900-0154-DRL</td>
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<td>900-0156-DRL</td>
<td>Summer School I (1 week)</td>
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<td>900-0157-DRL</td>
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<td>W 2 credits 4K</td>
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<tr>
<td>900-0159-DRL</td>
<td>Summer School I (1 week, with Poster or Talk)</td>
<td>W 3 credits 6K</td>
<td>Lecturers</td>
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<tr>
<td>900-0160-DRL</td>
<td>Summer School II (1 week, with Poster or Talk)</td>
<td>W 3 credits 6K</td>
<td>Lecturers</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Objective**
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
Summer School III (1 week, with Poster or Talk)  
Only for doctoral students.  

Abstract  
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.  

Objective  
Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

External Conference I (incl. Poster or Talk)  
Only for doctoral students.  

Abstract  
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.  

Objective  
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

External Conference II (incl. Poster or Talk)  
Only for doctoral students.  

Abstract  
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.  

Objective  
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

External Conference III (incl. Poster or Talk)  
Only for doctoral students.  

Abstract  
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Objective  
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Doctorate Management, Technology, and Economics - Key for Type

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Lecture</th>
<th>Lecture with Exercise</th>
<th>Exercise</th>
<th>Seminar</th>
<th>Colloquium</th>
<th>Practical/Laboratory Course</th>
<th>Independent Project</th>
<th>Diploma Thesis</th>
<th>Revision Course/Private Study</th>
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<tr>
<td>E-</td>
<td>O</td>
<td>W+</td>
<td>W</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
<td>Eligible for credits and recommended</td>
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<td>Dr</td>
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<td>Eligible for credits</td>
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ECTS  
European Credit Transfer and Accumulation System  

Special students and auditors need special permission from the lecturers.
<table>
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<tbody>
<tr>
<td>151-0111-00L</td>
<td>Research Seminar in Fluid Dynamics</td>
<td>E</td>
<td>0 credits</td>
<td>2S</td>
<td>F. Coletti, P. Jenny, O. Supponen</td>
</tr>
<tr>
<td>151-0123-00L</td>
<td>Experimental Methods for Engineers</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>D. J. Norris, F. Coletti, M. Lukatskaya, A. Manera, O. Supponen, M. Tabbitt</td>
</tr>
<tr>
<td>151-0225-00L</td>
<td>Material Characterization by X-ray Techniques:</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>P. M. Abdala, D. Piankova</td>
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<td></td>
<td>Diffraction, Absorption, Total Scattering</td>
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<tr>
<td>151-0529-00L</td>
<td>Nonlinear FEA</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>L. De Lorenzis</td>
</tr>
</tbody>
</table>

**Abstract**

- The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

**Objective**

To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.
Knowledge of advanced research in the areas of thermo- and fluid dynamics is presented and discussed, mostly by external speakers. Lecture notes will be provided. However, students are encouraged to take their own notes. Current advanced research activities in the areas of thermo- and fluid dynamics are presented and discussed, mostly by external speakers. Lecture notes will be provided. However, students are encouraged to take their own notes.

**Objective**

1. Introduction: various sources of nonlinearities and implications for FEA.

**Prerequisites / notice**

Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

### 151-0563-01L

**Dynamic Programming and Optimal Control**

**W 4 credits**

**2V+1U**

**R. D’Andrea**

**Abstract**

Introduction to Dynamic Programming and Optimal Control.

**Objective**

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Content**

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

**Literature**


**Prerequisites / notice**

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

### 151-0593-00L

**Embedded Control Systems**

**W 4 credits**

**6G**

**C. Onder, M. Schmid Daners**

**Abstract**

This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

**Objective**

Familiarize students with main architectural principles and concepts of embedded control systems.

**Content**

An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:

- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

**Lecture notes**

Lecture notes, lab instructions, supplemental material

**Prerequisites / notice**

Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischn@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

### 151-0623-00L

**ETH Zurich Distinguished Seminar in Robotics, Systems and Controls**

**W 1 credit**

**1S**

**B. Nelson, M. Hutter, R. Katzschmann, C. Menon, R. Riener, R. Siegwart**

**Abstract**

This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls.

**Objective**

Obtain an overview of various topics in Robotics, Systems, and Controls from leaders in the field. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a list of upcoming lectures.

**Content**

This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls. MSc students in Robotics, Systems, and Controls are required to attend every lecture. Attendance will be monitored. If for some reason a student cannot attend one of the lectures, the student must select another ETH or University of Zurich seminar related to the field and submit a one page description of the seminar topic. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a suggestion of other lectures.

**Prerequisites / notice**

Students are required to attend all seven lectures to obtain credit. If a student must miss a lecture then attendance at a related special lecture will be accepted that is reported in a one page summary of the attended lecture. No exceptions to this rule are allowed.

### 151-1053-00L

**Thermo- and Fluid Dynamics**

**E- 0 credits**

**2K**

**P. Jenny, R. S. Abhari, F. Coletti, G. Haller, C. Müller, N. Noiray, A. Steinfeld, O. Supponen**

**Abstract**

Current advanced research activities in the areas of thermo- and fluid dynamics are presented and discussed, mostly by external speakers.

**Objective**

Knowledge of advanced research in the areas of thermo- and fluid dynamics.

### 151-8101-00L

**International Engineering: from Hubris to Hope**

**W 4 credits**

**3G**

**E. Tilley**

**Abstract**

Since Europe surrendered their colonial assets, engineers from rich countries have returned to the African continent to address the real and perceived ills that they felt technology could solve. And yet, 70 years on, the promise of technology has largely failed to deliver widespread, substantive improvements in the quality of life. Why? After completing the course, participants will be able to:

- Critique the jargon and terms used by the international community, i.e. “development”, “aid”, “cooperation”, “assistance” “third world” “developing” “global south” “low and middle-income” and justify their own chosen terminology
- Recognize the role of racism and white-supremacy in the development of the Aid industry
- Understand the political, financial, and cultural reasons why technology and infrastructure have historically failed
- Debate the merits of international engineering in popular culture and media
- Propose improved SDG indicators that address current shortcomings
- Compare the engineering curricula of different countries to identify relative strengths and shortcomings
- Explain the inherent biases of academic publishing and its impact on engineering failure
- Analyze linkages between the rise of philanthropy and strategic priority areas
- Recommend equitable, just funding models to achieve more sustainable outcomes
- Formulate a vision for the international engineer of the future

**Objective**

This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to examine the complex role that well-meaning foreigners have played and continue to play in the disappointing health outcomes that characterize much of the African continent.
Content

Role of international engineering during colonialism
Transition of international engineering following colonialism
White saviourism and racism in international engineering
International engineering in popular culture
The missing role of Engineering Education
Biases in academic publishing
The emerging role in Global Philanthropy
The paradox of International funding

Literature


Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Competencies

Subject-specific Competencies

- Concepts and Theories: fostered
- Techniques and Technologies: fostered

Method-specific Competencies

- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered

Social Competencies

- Communication: fostered
- Customer Orientation: fostered

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

151-9901-00L Scientific Writing for Publication in Engineering

W 2 credits 1G

Abstract

Scientific Writing for Publication in Engineering is a short course (7 half-day workshops) designed to help junior researchers develop the skills needed to write their research articles in English.

Objective

- The course deals with topics such as
  - Fitting texts to target readerships and journals
  - Managing the writing process efficiently
  - Structuring each section of the text effectively
  - Producing fluent and reader-focused sentences and paragraphs
  - Editing the text before submission
  - Revising in response to reviewers’ comments.

Content

Participants produce a number of short texts as homework assignments and receive detailed individual feedback as well as peer feedback on these during the course. The course takes place at times and locations chosen to suit MAVT doctoral researchers. Content and materials deal specifically with the demands of writing in engineering research fields. Wherever feasible, elements of participants’ future research articles are developed as assignments within the course, so it is particularly useful for those who have their data and are about to begin the writing process.

Competencies

Subject-specific Competencies

- Concepts and Theories: fostered
- Techniques and Technologies: fostered

Method-specific Competencies

- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered

Social Competencies

- Communication: fostered

Personal Competencies

- Customer Orientation: fostered

151-9905-00L Applied Category Theory for Engineering I

Note: The previous course title until HS22 “Applied Compositional Thinking for Engineers II”

W 4 credits 3G A. Censi, J. Lorand

Abstract

Applied Category Theory is an exciting multidisciplinary field of research which harnesses the mathematical language of category theory for applications across a broad range of disciplines. This course is a gentle introduction focused on applications in engineering and the “compositional approach” to systems analysis, co-design, and computation.

Objective

1) Learn basic concepts from algebra and category theory, together with ways to make use of these concepts for engineering applications.

2) Become familiar with case studies of applied category theory, for instance involving dynamical systems, databases, and complex system co-design (e.g. in the context of autonomous vehicles).

3) Be able to recognize compositional structures in concrete scenarios at different levels of abstraction.

4) Understand the “compositional way of thinking” as an approach to systems analysis, co-design, and computation.
Discovering Management

**Objective**

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship. In particular, the aims of the course are to:

1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life management problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and appreciate the challenges that entrepreneurs and managers deal with.

**Content**

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by a set of area specialists at D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

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**Literature**


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Fong, Spivak, “An invitation to applied category theory: Seven sketches in compositionality”

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A knowledge of algebra at the level of a bachelor’s degree in engineering/computer science.

**Prerequisites / notice**

A knowledge of algebra at the level of a bachelor’s degree in engineering/computer science.

**351-0778-00L** Discovering Management

**Abstract**

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

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A knowledge of algebra at the level of a bachelor’s degree in engineering/computer science.

**Prerequisites / notice**

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Objective
The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

Literature

Prerequisites / notice
The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

Competencies

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363-0389-00L Technology & Innovation Management

W 3 credits 2G S. Brusoni, A. Zeijen

Abstract
This course focuses on the sources of innovation (with a specific focus on digital technologies), the tools and techniques that organizations deploy to innovate routinely, and the strategic implications of technical change at different levels of analysis: individuals, firms and whole ecosystems.

Objective
This course intends to enable all students to:
- Acquire and understand the basic jargon, concepts and methods necessary to discuss, in a precise and concise manner, innovation processes and their outcomes at different levels of analysis
- Analyze the differences between individual and organizational decision processes and their innovative outcomes
- Evaluate critically the potential of different (digital) technologies to impact business organizations.

Content
Organizations and people are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small. How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

Lecture notes
Slides will be available on the Moodle page

Literature
Readings will be available on the Moodle page

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics.

Competencies

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363-0403-00L Introduction to Marketing

W 3 credits 2G F. von Wangenheim, P. Bachmann

Abstract
This course provides an overview on essential perspectives of marketing and how marketing adds value to a business. It will teach concepts, frameworks and methods for marketing decision making. The course will also look at issues related to marketing implementation. Thereby, a particular focus will be on how data and data analytics can help to support marketers in their decision making.

Objective
After taking the class, students will be able to

1) Understand how marketing adds value to a business.
2) Provide an overview of key concepts in marketing that are applicable to any business.
3) Understand how consumers behave and how this impacts marketing
4) Learn how analytics and quantitative methods can help to improve decision making in marketing.
5) Get to know the elements that shape a firm’s marketing strategy (segmentation, targeting, positioning) and marketing tactics (product, price, promotion, place).

Content
The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their customers. It will teach concepts, frameworks and methods for marketing decision making. Specifically, the course is aims to provide students with a) an overview on the role of marketing within a business, b) details on strategic marketing management decisions and tools, c) a profound knowledge on the individual elements of the marketing mix (product, price, promotion, place), d) an awareness of specific contexts of marketing, and e) first-hand experience on data-driven techniques to support marketers’ decision making.

Thus, this course will introduce key analytical tools to help solving respective managerial tasks. This is a lecture with integrated exercises. Access to a laptop is required for the exercises. The class might be taught in an in-person, remote or in a hybrid format. Students might also be taught via pre-recorded videos and assigned material for self-study.

Literature

The course might comprise mandatory and supplemental reading material. Other literature may be assigned in class.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 824 of 2667
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

After attending the class, you should be able to:
- comment on the current events related to these topics
- become familiar with several classic decisions using managerial accounting information
- feel comfortable reading and using the information presented in companies’ annual reports
- understand cost concepts and conduct cost analyses

This course is a prerequisite for the course Financial Management.


This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

The course Accounting for Managers offers an introduction to financial and managerial accounting, especially for students who aspire for a career in business and management with a science or engineering background.

Accounting plays a critical role in the effective functioning of the financial market as well as the long-term success of a company. This course intends to provide an introduction to accounting for those who wish to pursue a career in business, and need the skills and knowledge to understand, analyze, and interpret accounting information to make informed decisions. The course is divided into two parts. In the first part, we focus on financial reporting and start with the basic accounting concepts and the accounting cycle, to learn how the financial system is set up in a company and how financial statements are prepared. We then delve deeper into each major account, and discuss how revenues and expenses are recognized, and how assets, liabilities, and equities are reported. In the second part, we focus on managerial accounting for internal managerial/operational decisions including fundamental topics such as cost behavior, cost estimation, CVP analyses, and relevant costing. We then cover budgeting and standard costing, which are important parts of accounting system in companies.
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real-life examples and cases.

### Competencies

- **Subject-specific Competencies**
  - Technology Entrepreneurship
    - Objective: Assessed
    - Content: Fostered

### Literature


### Prerequisites / notice

Basic knowledge in international economics and a good background in macroeconomics.

### Competencies

- **Methods-specific Competencies**
  - Analytical Competencies
  - Problem-solving

- **Social Competencies**
  - Communication
  - Cooperation and Teamwork
  - Sensitivity to Diversity

- **Personal Competencies**
  - Negotiation
  - Adaptability and Flexibility
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

### Analysis of Variance and Experimental Design

- **Abstract**
  - Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

- **Objective**
  - Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

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Abstract
Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Introduction into intellectual property; prosecution of patent applications; patent information; exploitation and enforcement of patents; peculiarities in pharmacetics and medicine; social, political and ethical aspects; Trademarks.

Objective
Basic knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

Content
1. Introduction into industrial property (patents, trademarks, industrial designs);
2. Prosecution of patent applications (patentability);
3. Patent information (patent publications, databases, searches);
4. Exploitation and enforcement of patents (possibilities of exploitation, licenses, parallel imports, scope of protection, patent infringement);
5. Peculiarities in pharmacetics and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication);
6. Social, political and ethical aspects (patents and prices for medicinal products, traditional knowledge and ethnomedicine, bioprospecting and biopiracy, human DNA inventions);
7. Trademarks, types of trademarks, grounds for refusal, peculiarities of pharma-trademarks.

Lecture notes
A script is provided in electronic form during the lecture.

Literature

Prerequisites / notice
None

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Transferrable Skills

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<td>Ethics and Scientific Integrity for Doctoral Students (MaP Doctoral School)</td>
<td>W</td>
<td>1</td>
<td>2</td>
<td>M. Trassin, K. M. Berg, A. Lauria, S. Stepanow</td>
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Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a discipline specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

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Part I
The self-paced e-learning course consists of 5 modules:
(1) Ethics: Introduction to moral theory (with emphasis on practical guidance regarding decision making)
(2) Ethics in Scientific Research: Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).
(3) Collecting Resources: A variety of tools and resources that help identify ethical issues are presented and explained
(4) Setting up a Strategy: Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).
(5) Making Decisions: Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects of Materials, Processes and Manufacturing Technologies. It provides an interactive learning environment. Participants get to apply their knowledge, and they are encouraged to reflect on ethical problems and critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only

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### Integration into Scientific Community

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<td>900-0154-DRL</td>
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<td>900-0157-DRL</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

**Objective**

Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

---

### 900-0160-DRL Summer School II (1 week, with Poster or Talk)

**W** 3 credits 6K **Lecturers**

*Only for doctoral students.*

**Abstract**

Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

---

### 900-0161-DRL Summer School III (1 week, with Poster or Talk)

**W** 3 credits 6K **Lecturers**

*Only for doctoral students.*

**Abstract**

Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

---

### 900-0162-DRL External Conference I (incl. Poster or Talk)

**W** 1 credit 2K **Lecturers**

*Only for doctoral students.*

**Abstract**

Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

---

### 900-0163-DRL External Conference II (incl. Poster or Talk)

**W** 1 credit 2K **Lecturers**

*Only for doctoral students.*

**Abstract**

Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

---

### 900-0164-DRL External Conference III (incl. Poster or Talk)

**W** 1 credit 2K **Lecturers**

*Only for doctoral students.*

**Abstract**

Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

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**Doctorate Mechanical and Process Engineering - Key for Type**

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
<th>Z</th>
<th>Courses outside the curriculum</th>
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<tbody>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
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**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<td>K</td>
<td>colloquium</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Subject Specialisation

### General Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0711-00L</td>
<td>Metal Physics and Technology Seminar</td>
<td>E-</td>
<td>0</td>
<td>2S</td>
<td>J. F. Löfler</td>
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<td>Abstract</td>
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<tr>
<td></td>
<td>Detailed education of researchers in the area of metal physics and technology.</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td></td>
<td>Problem-solving</td>
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<td>Communication</td>
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<td></td>
<td>Organising and discussing latest research results concerning basic principles of metals research and development of new metallic materials.</td>
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<td></td>
<td>- Requirements: Involvement in research activities.</td>
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<td>- Lectures are generally in English.</td>
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<tr>
<td>327-0712-00L</td>
<td>Nanometallurgy</td>
<td>E-</td>
<td>0</td>
<td>2S</td>
<td>R. Spolenak</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>Detailed education of researchers in the area of nanometallurgy.</td>
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<td>327-1300-00L</td>
<td>Joint Group Seminar</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>M. Fiebig, N. Spaldin</td>
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<td>Abstract</td>
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<td>Seminar for PhD students and researchers in condensed-matter physics.</td>
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<td>Improving the interaction of researchers in the participating groups.</td>
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<td>Content</td>
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<td></td>
<td>Presentation and discussion of contemporary research.</td>
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<tr>
<td>327-6100-00L</td>
<td>Materials Colloquium</td>
<td>E-</td>
<td>0</td>
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<td>Professors, further speakers</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>The Materials Colloquium is a platform for PhD students, postdoctoral researchers, group leaders, senior scientists, and professors to present their own and their group’s research to their colleagues. The apero following the colloquium has the purpose to stimulate discussions and to promote networking in a relaxed, more informal environment. The Colloquium is open to all who are interested.</td>
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<td>Learn about recent research in the field of materials science.</td>
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<td>327-0721-00L</td>
<td>Writing for Publication in Materials Science</td>
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<td></td>
<td>Abstract</td>
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<td>This short course is designed to help junior researchers in Materials Science develop the skills needed to write their first research articles.</td>
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<td>Writing for Publication in Materials Science is a short course (5 x 4-lesson workshops) designed to help junior researchers develop the skills needed to write their first research articles. The course deals with topics such as</td>
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<td>- identifying target readerships and selecting outlets,</td>
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<td>- managing the writing process efficiently,</td>
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<td>- structuring the text effectively,</td>
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<td>- producing logical flow in sentences and paragraphs,</td>
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<td>- editing the text before submission, and</td>
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<td>- revising the text in response to reviewers' comments.</td>
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<td>Participants are advised to take this course once they have enough research to begin writing so as to be able to get feedback on work in progress. They will be expected to produce a number of short texts as homework assignments and will receive individual feedback from the instructor and peer feedback on these during the course. Wherever feasible, elements of participants' future research articles can be developed for these assignments, so it is likely to be particularly useful for those who have their data and are about to begin the writing process.</td>
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<td>Part 1: Part 1 will provide an introduction to the course, and will then focus on using model texts, improving vocabulary and phrasing, and constructing reader-friendly sentences.</td>
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<td>Part 2: We will discuss structural decisions about research articles in different journals, review the basics of paragraph structure and organization, and examine how to create better flow in a text.</td>
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<td>Part 3: We will work on creating successful introductions, integrating the literature, and writing abstracts.</td>
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<td>Part 4: Part 4 will address the main content and grammar concerns of writing about methods and results, and review key grammar concepts for writing complex sentences.</td>
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<td>Part 5: We will look at how to construct discussion and conclusion sections and how to strike the right tone of caution/confidence. We will then discuss the editing process, preparing articles for submission, and responding to reviewers' comments.</td>
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<td>All sessions will involve group work and peer review of participants' writing.</td>
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<td>Prerequisites / notice</td>
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<td>Method-specific Competencies</td>
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<td>Critical Thinking</td>
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<td>Creative Thinking</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<td>Detailed education of researchers in the area of microscopy.</td>
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<td>The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.</td>
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<td>For PhD students, postdocs and others, a fee will be charged (<a href="https://scopem.ethz.ch/education/MTP.html">https://scopem.ethz.ch/education/MTP.html</a>).</td>
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<td>All applicants must additionally register on this form:</td>
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</table>
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments. This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Literature
- Practice on real-world samples and report results
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Prerequisites / notice
No mandatory prerequisites.
Modern polymer synthesis (based on recent development of new organic reactions) is discussed to enable students to develop synthesis schemes for certain target structures. Both chain (ionic, coordination, ROMP, radical, catalyst-transfer) and step-growth polymerizations (transition metal catalysis) including how to achieve living polymerization or improve selectivity will be discussed.

Students should be able to: Identify important polymerization procedures and types of polymerization. Predict reactivities of monomers based on the chemical structures. Devise synthetic pathways to produce a given polymer structure. Evaluate properties of macromolecules based on structure and synthesis method. Develop synthesis schemes for target structures and discuss potential applications of polymers.

Polymerization is a series of continuous organic transformations and connects small molecules. The course will give an overview of the following important polymerization procedures:

- Modern Step-growth polymerization
- Living Anionic polymerization
- Group transfer polymerization (GTP)
- Controlled cationic polymerization
- Controlled radical polymerization
- Coordination polymerization: Ziegler-Natta and Metallocene catalysts
- Olefin metathesis polymerization: ROMP, ADMET and cyclopolymerization
- Synthesis of conjugated polymers based on transition metal catalysis
- Complex macromolecules including brush and dendronized polymers

Students will learn how to deal with chemical structures and reactivities, and be able to suggest reasonable synthetic pathways to a given polymer structure, like conjugated polymers based on transition metal catalysis or complex macromolecules including brush and dendronized polymers. Aspects like controlling molar masses and structure perfection play a role throughout. The course provides the students with a high-level overview of modern methods of polymer synthesis both in theoretical and practical aspects. It should enable them to develop reasonable synthesis schemes for certain target structures and also to predict the properties of given macromolecules. For all polymers presented, potential or real applications will be discussed.

The FIRST Introduction Day comprises general and access information, cleanroom basics, infrastructure information, safety training, cleanliness seminar, chemistry seminar and safety test. The introduction day is mandatory for each user who intends to use the FIRST cleanrooms independently of level of experience.

The PhD-level course (primarily for A&T PhDs) will introduce computational methods for architecture, engineering, fabrication & construction, incentivising computational literacy. Students learn the theoretical background and basic implementation details of fundamental data structures and algorithms, and to solve real-world problems using the COMPAS framework and other open-source libraries.

Understand the scope and relevance of computational methods for architecture and engineering research and practice, i) the theoretical background of fundamental data structures, iii) the basic principles of algorithmic design; iv) implement basic versions of prevalent algorithms related to architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation; v) use sophisticated algorithms available through open-source libraries to solve real-world problems; and, vi) use common CAD tools as interfaces to self-implemented solutions.

Course consists of a few lectures, several tutorials and project-based exercises. Topics include:

- intro Python programming
- intro COMPAS open-source framework (https://compas-ev.github.io
- intro to geometry processing, data structures, topology, numerical computation
- domain-specific case studies (e.g. on architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation)

Priority is given to PhD students.
Objective

This course aims to provide a graduate-level introduction to machine learning, with a particular focus on scientific machine learning for applications in the design and construction phases of projects from architecture and civil engineering.

Upon completion of the course, the students will be able to:
1. Understand main ML background theory and methods.
2. Assess a problem and apply ML and DL in a computational framework accordingly.
3. Incorporate scientific domain knowledge in the SciML process.
4. Define, plan, conduct and present a SciML project.

Content

The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
2. Incorporation of Domain Knowledge into ML and DL.
4. ML training, validation and testing pipelines for academic and research projects.

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

Lecture notes

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Literature

Suggested Reading:
3) FRP Reinforced Concrete, All FRP Structures

Prerequisites / notice

Familiarity with Python is advised.

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking
Self-direction and Self-management

101-0167-01L Fibre Composite Materials in Structural Engineering W 3 credits 2G M. Motavalli

Abstract

1) Lamina and Laminate Theory
2) FRP Manufacturing and Testing Methods
3) Design and Application of Externally Bonded Reinforcement to Concrete, Timber, and metallic Structures
4) FRP Reinforced Concrete, All FRP Structures
5) Measurement Techniques and Structural Health Monitoring

Objective

At the end of the course, you shall be able to
1) Design advanced FRP composites for your structures,
2) To consult owners and clients with necessray testing and SHM techniques for FRP structures,
3) Continue your education as a phd student in this field.

Content

Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring technologies. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

Lecture notes

3) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019

Prerequisites / notice

1) Laboratory Tours and Demonstrations: Empa Structural Engineering Laboratory including FRP Composites, Shape Memory Alloys, Timber Elements, Large Scale Testing of Structural Components
2) Working with Composite Materials in the Laboratory (application, testing, etc)

102-0357-00L Waste Recycling Technologies W 3 credits 2G M. Haupt, V. Burg

Abstract

Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

Objective

At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 835 of 2667
Introduction
Waste Recycling: Scope and objectives
Waste recycling technologies in Switzerland

Fundamentals
Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials
Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
Flow sheet basics: Balancing mass flows
Standard processes; batch vs. continuous
Assessment of separation success: Separation function; grade vs. recovery

Separation Processes
Separation according to size and shape (Classification): Screening, Flow separation
Separation according to material properties (Concentration): Manual Sorting, Gravity concentration; Magnetic separation, Eddy current separation, Electrostatic separation, Sensor technology, Froth flotation

Lecture notes
The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Prerequisites / notice
The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

151-0293-00L Fundamentals and Applications of Combustion

Abstract
This course will provide an introduction to the fundamentals and the applications of combustion in energy conversion and nanoparticles synthesis. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

Objective
The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

Content
Reaction kinetics, fuel oxidation mechanisms, premixed and diffusion laminar flames, two-phase-flows, turbulence and turbulent combustion, pollutant formation, development of sustainable combustion technologies for power generation, shipping and aviation.

Lecture notes
No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:
Teaching language, assignments and lecture slides in English

Literature

151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems.
The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

Lecture notes
The handout is available in German and English.

Prerequisites / notice
"Visualization, Simulation and Interaction - Virtual Reality I" is recommended, but not mandatory.

Competencies
Subject-specific Competencies
Concepts and Theories
Assessed
Techniques and Technologies
Assessed
Method-specific Competencies
Analytical Competencies
Assessed
Media and Digital Technologies
Assessed
Social Competencies
Communication
Assessed
Cooperation and Teamwork
Assessed
Personal Competencies
Creative Thinking
Assessed
Critical Thinking
Assessed

151-0353-00L Mechanics of Composite Materials

Abstract
The courses treats aspects related to elastic behavior of unidirectional and multidirectional laminates, micromechanics, failure and damage analysis, analysis and design of composite structures. The focus is on laminated fiber-reinforced polymer composites.

Objective
The objective is to introduce the basic concept of composite materials and provide a thorough understanding of the mechanical response of such materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.
The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics & Homogenization
- Classical Lamine Theory (CLT)
- Strength, failure and damage analysis
- Thin ply composite shells & effects of material non-linearity
- Analysis and design of composite structures

The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

The previous course title until HS22 "Metal Additive Manufacturing - Mechanical Integrity and Process Simulation" Note: The previous course title until HS22 "Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis"

An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using commercial analysis tools (e.g. ABAQUS) for simulation of the MAM process.

- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (stainless steel, Ti6Al4V, Inconel 718),
- Design for additive manufacturing
- Artificial intelligence for AM

Exercise sessions use ABAQUS for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. Students can install the packages on their own systems.

Handouts of the presented slides.

No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).
Prerequisites / notice

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork

Personal Competencies

- Creative Thinking
- Critical Thinking

151-0623-00L ETH Zurich Distinguished Seminar in Robotics, Systems and Controls

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2V+1U</th>
</tr>
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<tbody>
<tr>
<td>ETH Zurich Distinguished Seminar in Robotics, Systems and Controls</td>
<td>B. Nelson, M. Hutter, R. Katzschmann, C. Menon, R. Riener, R. Siegwart</td>
<td></td>
</tr>
</tbody>
</table>

Abstract

This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls.

Objective

Obtain an overview of various topics in Robotics, Systems, and Controls from leaders in the field. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a list of upcoming lectures.

Content

This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls. MSc students in Robotics, Systems, and Controls are required to attend every lecture. Attendance will be monitored. If for some reason a student cannot attend one of the lectures, the student must select another ETH or University of Zurich seminar related to the field and submit a one page description of the seminar topic. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a suggestion of other lectures.

Prerequisites / notice

Students are required to attend all seven lectures to obtain credit. If a student must miss a lecture then attendance at a related special lecture will be accepted that is reported in a one page summary of the attended lecture. No exceptions to this rule are allowed.

151-0703-00L Operational Simulation of Production Lines

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<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2V+1U</th>
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<tbody>
<tr>
<td>Operational Simulation of Production Lines</td>
<td>P. Acél, A. Kunz</td>
<td></td>
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</table>

Abstract

The students learn the application of the event-based and computer-based simulation for layout and improvement of production facilities by means of practical examples and by using the so-called "Digital Twin" within the context of "Industry 4.0". They learn how virtual and mixed reality tools can be used together with the Digital Twin to plan and support the operation of a production line.

Objective

The students learn the correct use of (Who? When? How?) of the event-driven and computer-based simulation in the illustration of the operating procedures and the production facilities. The simulation is an important basis for creating a digital twin in the context of Industry 4.0.

Content

- Application and application areas of the event-driven simulation
- Simulation in the context of Industry 4.0 (digital twin)
- Exemplary application of a software tool (Technomatrix-Simulation-Software)
- Internal organization and functionality of simulation tools
- Procedure for application: optimizing, experimental design planning, analysis, data preparation
- Controlling philosophies, emergency concepts, production in sequence, line production, rescheduling
- Application on the facilities projecting
- Application of Virtual and Mixed Reality
- Procedure for application: optimizing, experimental design planning, analysis, data preparation
- Controlling philosophies, emergency concepts, production in sequence, line production, rescheduling
- Application on the facilities projecting

The knowledge is enhanced by practice-oriented exercises and an excursion. A guest speaker will present a practical example.

Lecture notes

Will be sent by email before the lecture (pdf).

Literature

A bibliography will be handed out during the lectures.

Prerequisites / notice

Recommended for all Bachelor-Students in the 5th semester and Master-Students in the 7th semester (MAVT, MTEC, PhD students in material sciences) and for all with interest in production (e.g., MTEC, HEST, etc.)

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies

- Cooperation and Teamwork

Personal Competencies

- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

151-0727-00L Colloquium on Manufacturing Technology

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2.5K</th>
</tr>
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<tbody>
<tr>
<td>Colloquium on Manufacturing Technology</td>
<td>A. Kunz</td>
<td></td>
</tr>
</tbody>
</table>

Abstract

Future training on selected current topics of the manufacturing technology. Per afternoon a selected topic is presented in several lectures, by the majority by experts from the industry. The students prepare a summary of the lectures given and prepare themselves on the basis of these lectures and own information search.

Objective

Contious further training to current topics of the manufacturing technique. Exchange of experience and knowledge with the industry and other universities.

Content

Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

Lecture notes

no Script
Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite Element Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite Elements are simulations of:

- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.

The course includes a project based on real world challenges where students design, fabricate and iteratively optimize functional AM parts using an appropriate AM technology.

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

This course provides a basic knowledge of design for additive manufacturing (AM). The course will prepare students to

- Apply basic AM processes (metal and plastic)
- Apply AM design guidelines
- Adopt AM in an industrial environment
- Apply design tools and methods in AM
- Create value from AM
- Work in a project based product development team

The course covers the following topics:

- State-of-the-art AM processes for metals and plastics: PBF (also known as SLM, SLS), BJT, MJF, MEX (FDM)
- Design guidelines in AM
- Industrial adoption of AM
- Value creation and business models for AM
- Design tools and methodologies for AM
- Quality management in AM
- Industrial cases of AM applications
- Problem solving and creativity
- Agile development

The course covers the fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.

The course includes a project based on real world challenges where students design, fabricate and iteratively optimize functional AM parts using an appropriate AM technology.

This course focuses on the design, manufacture and testing of components produced using additive manufacturing (AM) technologies. The course includes a project based on real-world challenges where students design, fabricate and iteratively optimize functional AM parts using an appropriate AM technology.

The course covers the following topics:

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- Industrial adoption of AM
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- Design guidelines in AM
- Industrial adoption of AM
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- Design tools and methodologies for AM
- Quality management in AM
- Industrial cases of AM applications
- Problem solving and creativity
- Agile development

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- State-of-the-art AM processes for metals and plastics: PBF (also known as SLM, SLS), BJT, MJF, MEX (FDM)
- Design guidelines in AM
- Industrial adoption of AM
- Value creation and business models for AM
- Design tools and methodologies for AM
- Quality management in AM
- Industrial cases of AM applications
- Problem solving and creativity
- Agile development
Abstract
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

Objective
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:
1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

Content
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM, Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Literature
Suggested literature is provided in the syllabus.
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as micro lithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Objective

Introduction to lasers, Overview of micro- and nanotechnology, microlithography, photoresists: classical types and new developments, laser cutting and welding, laser cleaning, laser ablation, polymer ablation: designed polymers, lasers and surfaces, laser spectroscopy, laser chemical vapor deposition, pulsed laser deposition (PLD), special materials by PLD, alternative structuring methods.

Content

The Chemical Product Design course teaches students quantitative concepts to analyze, select and transform theoretical concepts from chemistry and engineering into valuable real-world products. Basic chemistry and chemical engineering knowledge is required (Diffusion, Thermodynamics, Kinetics...).

Abstract

This course starts with analyzing existing chemical needs and unmet technical challenges. We then develop the skills to critically analyze a specific chemical idea for a product, to rapidly test feasibility or chance for success and to eventually realize its manufacturing. The chemical engineering basics are then used to assess performance of products or devices with non-traditional functions based on dynamic properties (e.g. responsive building materials; personal medical diagnostics on paper strips). The course teaches the interface between laboratory and market with a specific focus on evaluating the chemical value of a given process or compound, and the necessary steps to pursue the resulting project within an entrepreneurial environment. We therefore extend the questions of process design ('how do we make...') to the question of 'what should we make?'
Part A: The 'Chemical Product Design' course starts with discussing questions along, 'What is a chemical product, and why do people pay for it? How does a given compound in a specific setting provide a service?' We then learn how to translate new, often ill-defined wishes or ideas into quantifiable specifications.

Part B: Thermodynamic and kinetic data allow sharp selection criteria for successful products. We learn how to deal with insufficient data and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation units as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value generated.

Students are expected to actively develop chemical products along the course during the exercise sessions. Contributions will be made in small groups, where a larger topic is studied. The progress of each group will be followed by reports and short presentations during the semester, and one final pitching presentation at the end of the semester. Active participation in the group projects is mandatory for the admission to the oral exam.

Literature


Prerequisites / notice
Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...).

.openapi##Science & Technology of the Small (MaP Doctoral School)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0409-00L</td>
<td>Multiphysics Modeling and Simulation</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>C. I. Roman</td>
</tr>
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Abstract
This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

Objective
As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling. Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

Content
- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

Lecture notes
Lecture handouts will be posted online.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

.openapi##Acoustics in Fluid Media: From Robotics to Additive Manufacturing

Abstract
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.
Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices

Lecture notes

Literature

Prerequisites / notice
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-direction and Self-management: assessed

151-0604-00L  Microrobotics  W  4 credits  3G  B. Nelson

Abstract
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

151-0620-00L  Embedded MEMS Lab  W  5 credits  3P  C. Hierold, A. Güntner, M. Haluska

Abstract
Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report.

Objective
Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

Content
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

Lecture notes
A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

Literature
The document provides sufficient information for the participants to successfully participate in the course.
Prerequisites / notice

Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAYT-tutors Profs Daraio, Dual, Hierold, Kaumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

**151-0621-00L Microsystems I: Process Technology and Integration**

*Abstract*

Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and devices by a sequence of defined processing steps (process flow).

*Objective*

Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (process flow).

*Content*

- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

Application of selected technologies will be demonstrated on case studies.

*Lecture notes*

Handouts (available online)

*Literature*

- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystems Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

*Prerequisites / notice*

Prerequisites: Physics I and II

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**151-0913-00L Introduction to Photonics**

*Abstract*

This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

*Objective*

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarization control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel coefficients
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Applications of optical tweezers

VII- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

227-0053-00L High-Frequency Design Techniques W 4 credits 2V+2U C. Bolognesi, T. Popovic

Abstract
Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible: higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Objective
Familiarize students with the essential tools and principles exploited in the high-frequency design. Introduction to circuit simulation. Introduction to amplifier design.

Content
Introduction to wireless, radio spectrum. Review of vectors and complex numbers, AC circuit analysis, matching networks, distributed circuit design, transmission lines and transmission line equations, reflection coefficients, the Smith Chart and its software, voltage standing wave ratio (VSWR), skin effect, matrix analysis, scattering parameters, electromagnetic fields and waves, amplifier design. Hands-on experience with measurement equipment.

Lecture notes
A detailed script is provided for each lecture, including the exercises and their solutions.

Literature
### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
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<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</tbody>
</table>

### Electromagnetic Waves: Materials, Effects, and Antennas

**W** 6 credits 4G

**227-0110-00L**

**Abstract**

This course provides profound knowledge about electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.

**Objective**

You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions. You know how waves interact with matter and about nonlinear, scattering and resonant effects. You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.

**Content**

The lecture covers the following topics:

- Generic time-harmonic electromagnetic fields
- Fundamental solutions of the wave equation
- Wave propagation in various types of materials
- Interaction of waves with matter
- Nonlinear effects
- Resonant effects
- Applications like scattering, waveguiding, radiation
- Radio frequency and optical antennas

**Lecture notes**

Lecture notes and slides will be handed out during the lectures.

**227-0157-00L**

**Semiconductor Devices: Physical Bases and Simulation**

**W** 4 credits 3G

**A. Schenk, C. I. Roman**

**Abstract**

The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics, and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

**Objective**

The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics, and device physics is provided.

**Content**

The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

**Lecture notes**

The script (in book style) can be downloaded from: https://iis-students.ee.ethz.ch/lectures/

**Literature**

The script (in book style) is sufficient. Further reading will be recommended in the lecture.

**Prerequisites / notice**


**227-0311-00L**

**Qubits, Electrons, Photons**

**W** 6 credits 3V+2U

**T. Zambelli**

**Abstract**

In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

**Objective**

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EET (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

**IMPORTANT:** “qubits” from the point of view of NMR (and NOT from that of quantum computing!).

**Content**

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener
Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM, while corresponding videos of the previous years are available in Moodle !!!!

Literature

Supplementary material will be uploaded in Moodle.

- (as rigorous and profound presentation of the mathematical framework) G. Dell'Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer
- (as account of those formidable years) G. Gamow, "Thirty Years that Shook Physics", 1985, Dover Publications Inc.

Prerequisites / notice
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET "Physics II".

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Competencies on the right side of the page are fostered; those on the right side of the page are assessed.

Simulation of Photovoltaic Devices - From Materials to Modules

W 3 credits 2G U. Aeberhard

Abstract
The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules.

Objective
Get an overview of the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to analyze, optimize, and predict the performance of solar cells and modules.

Content
Photovoltaic technology; history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CxTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture)

Literature

Prerequisites / notice
Undergraduate physics (including basic quantum mechanics); mathematics, semiconductor devices, optics. Knowledge of some scripting language (e.g. python) is of advantage.
Competencies | Subject-specific Competencies | Concepts and Theories | assessed
---|---|---|---
| Techniques and Technologies | assessed
| Method-specific Competencies | Analytical Competencies | assessed
| Decision-making | fostered
| Media and Digital Technologies | fostered
| Problem-solving | assessed
| Project Management | fostered
| Social Competencies | Communication | fostered
| Cooperation and Teamwork | fostered
| Customer Orientation | fostered
| Leadership and Responsibility | fostered
| Self-presentation and Social Influence | fostered
| Sensitivity to Diversity | fostered
| Negotiation | fostered
| Personal Competencies | Adaptability and Flexibility | fostered
| Creative Thinking | assessed
| Critical Thinking | assessed
| Integrity and Work Ethics | fostered
| Self-awareness and Self-reflection | fostered
| Self-direction and Self-management | fostered

227-0654-00L Carbon-based Nanoelectronics

Abstract
This course explores the exciting realm of carbon-based nanoelectronics, where the remarkable quantum properties of materials like graphene, carbon nanotubes, graphene nanoribbons, and single molecules are used for building electronic devices.

Objective
The objective of this course is to understand how the electronic properties of carbon-based materials can be exploited for fabricating quantum devices. We will delve into both the theoretical and experimental aspects, discussing how these materials’ unique properties can be translated into device functionality.

On the theoretical side, we’ll cover how the chemical structure of the material and its dimensionality, ranging from 0D to 2D, affects the electronic properties. We’ll also discuss how charge carriers flow through the devices and what charge transport mechanisms are at play.

On the experimental side, we’ll cover how such devices are fabricated, including how the materials are synthesized. We’ll also discuss how to characterize the devices and assess their performance.

Content
The course will cover the following carbon-based materials:
- Single-molecule
- Graphene (single layer, bilayer, twisted bilayer)
- Graphene nanoribbons
- Carbon nanotubes

For each material, we will discuss:
- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

The course also includes a presentation by each student in which a related scientific publication is discussed. This presentation is compulsory and accounts for 30% of the grade.

Lecture notes
Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

Literature
In addition to the slides, the following supplementary books can be recommended:

Prerequisites / notice
A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

Competencies

<table>
<thead>
<tr>
<th>227-0663-00L Nano-Optics</th>
<th>W</th>
<th>6 credits</th>
<th>2V+2U</th>
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</thead>
<tbody>
<tr>
<td>M. Frimmer</td>
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</table>

Abstract
Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Objective
Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

Content
We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

Prerequisites / notice
- Electromagnetic fields and waves (or equivalent)
- Physics I+II

Competencies

<table>
<thead>
<tr>
<th>227-1635-00L Electric Circuits</th>
<th>W</th>
<th>4 credits</th>
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<tbody>
<tr>
<td>D. Shchetinin</td>
<td>3G</td>
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</tbody>
</table>

Does not take place this semester.

Abstract
Electric Circuits is the study of the control and interaction of signals in a variety of linear and non-linear systems. It is the study of the properties of objects that can be represented by linear equations. The objectives of this course are to introduce the fundamental concepts of circuit analysis and to develop skills in applying these concepts to the analysis and design of electrical circuits.

Objective
This course will provide a comprehensive introduction to the theory and application of circuits and electrical systems, with a strong emphasis on problem-solving techniques and practical applications.

Content
The course will cover the following topics:
- Circuit analysis
- DC and AC circuit analysis
- Network theorems
- Transistor circuits
- Operational amplifiers
- Feedback systems
- Simple analog and digital signal processing
- Active filter design

Prerequisites / notice
A basic knowledge of elementary algebra and basic electronics is required. Familiarity with calculus is recommended but not required.

227-0654-00L Carbon-based Nanoelectronics

Abstract
This course explores the exciting realm of carbon-based nanoelectronics, where the remarkable quantum properties of materials like graphene, carbon nanotubes, graphene nanoribbons, and single molecules are used for building electronic devices.

Objective
The objective of this course is to understand how the electronic properties of carbon-based materials can be exploited for fabricating quantum devices. We will delve into both the theoretical and experimental aspects, discussing how these materials’ unique properties can be translated into device functionality.

On the theoretical side, we’ll cover how the chemical structure of the material and its dimensionality, ranging from 0D to 2D, affects the electronic properties. We’ll also discuss how charge carriers flow through the devices and what charge transport mechanisms are at play.

On the experimental side, we’ll cover how such devices are fabricated, including how the materials are synthesized. We’ll also discuss how to characterize the devices and assess their performance.

Content
The course will cover the following carbon-based materials:
- Single-molecule
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- Graphene nanoribbons
- Carbon nanotubes

For each material, we will discuss:
- Electronic structure and charge transport properties
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- Device integration and characterization

The course also includes a presentation by each student in which a related scientific publication is discussed. This presentation is compulsory and accounts for 30% of the grade.

Lecture notes
Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

Literature
In addition to the slides, the following supplementary books can be recommended:

Prerequisites / notice
A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

Competencies

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Objective
Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

Content
We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

Prerequisites / notice
- Electromagnetic fields and waves (or equivalent)
- Physics I+II

Competencies

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Electric Circuits is the study of the control and interaction of signals in a variety of linear and non-linear systems. It is the study of the properties of objects that can be represented by linear equations. The objectives of this course are to introduce the fundamental concepts of circuit analysis and to develop skills in applying these concepts to the analysis and design of electrical circuits.

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Content
The course will cover the following topics:
- Circuit analysis
- DC and AC circuit analysis
- Network theorems
- Transistor circuits
- Operational amplifiers
- Feedback systems
- Simple analog and digital signal processing
- Active filter design

Prerequisites / notice
A basic knowledge of elementary algebra and basic electronics is required. Familiarity with calculus is recommended but not required.
This course teaches the basics of surface and interface science and technology, including surface modifications and forces. It covers:

- Introduction to surfaces and interfaces
- Script Download:
- Analytical Competencies
- L. Isa
- Introduction to analysis methods and network theorems to describe operation of electric circuits. Theoretical foundations are essential for
- Subject-specific Competencies
- Students are able to
- fostered
- Creative Thinking
- Concepts and Theories
- assessed
- At the end of this course, the student will be able to: understand variables in electric circuits, evaluate possible approaches and analyze
- Method-specific Competencies
- Subject-specific Competencies
- Surfaces and Interfaces I: Fundamentals, Analytics
- 3G
- Lecture slides and exercises slides
- - Case studies
- - Other types of phoresis
- - Contact angles
- - Wetting
- - Boundary lubrication
- - Wettability
- - Contact angles
- - Phoretic phenomena
- - Electric double layer and electrophoresis
- - Electro-osmosis
- - Phoretic phenomena
- - Contact angles
- - Wetting
- - Boundary lubrication
- - Wettability
- - Contact angles
- - Phoretic phenomena
- - Electric double layer and electrophoresis
- - Electro-osmosis
- Surfaces and Interfaces I: Fundamentals, Analytics and Applications
- W 6 credits 3G L. Isa, M. P. Heuberger
- 327-0505-00L

Abstract
Introduction to analysis methods and network theorems to describe operation of electric circuits. Theoretical foundations are essential for the analysis of the electric power transmission and distribution grids as well as many modern technological devices – consumer electronics, control systems, computers and communications.

Objective
At the end of this course, the student will be able to: understand variables in electric circuits, evaluate possible approaches and analyze simple electric circuits with RLC elements at steady state and during transients, apply circuit theorems to simple meshed circuits, analyze AC circuits and understand the connection of the explained principles to the modelling of 3-phase electric power systems.

Content
Course will introduce electric circuits variables, circuit elements (resistive, inductive, capacitive), resistive circuits and theorems (Kirchhoff's laws, Norton and Thévenin equivalents), nodal and mesh analysis, superposition principle; it will continue by discussing the complete response of RL, RC and RLC circuits during transients, sinusoidal analysis – AC steady state (complex power, reactive, active power) and conclude with the introduction to 3-phase analysis;

Mathematical foundations of the circuit analysis, such as matrix operations and complex numbers will be briefly reviewed. This course is targeting students who have no prior background in electrical engineering.

Lecture notes
Lecture and exercises slides will be distributed after each lecture via Moodle platform; additional materials to be accessed online (wileyplus)

Literature
Richard C. Dorf, James A. Svoboda
Introduction to Electric Circuits, 9th Edition
Online materials: https://www.wileyplus.com/
Lecture slides and exercises slides

Prerequisites /
This course is primarily intended for students outside of D-ITET. No prior course in electrical engineering is required.

Competencies
- Subject-specific Competencies
- Concepts and Theories
- assessed
- Techniques and Technologies
- assessed
- Method-specific Competencies
- Analytical Competencies
- Problem-solving
- assessed
- Personal Competencies
- Creative Thinking
- Critical Thinking
- assessed
Abstract
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content
This course provides a general introduction into electron- and ion-microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, focused ion-beam and atom probe microscopes are presented. Throughout the semester, various applications in materials science, solid state physics, structural biology, structural geology, and structural chemistry will be reported.

Lecture notes
will be distributed in English

Literature
Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Problem-solving assessed

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered

Literature
- Scattering Techniques for Material Characterization: X-ray diffraction (XRD) and transmission electron microscopy (TEM). The theoretical basics, instrumentation, complementarity and exclusivity of both techniques will be taught. The course includes practical elements and examples of current research projects at D-MATL.

Prerequisites
- Crystallography, X-ray diffraction and electron microscopy on the BSc level. All enrolled students are initially placed on the "waiting list" until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed

327-0703-00L Electron Microscopy in Material Science

327-2137-00L Scattering Techniques for Material Characterization

327-2208-00L Order in Materials
Abstract

The aim is an overview of the different ordering phenomena that occur in materials: magnetic, electrical, mechanical, structural. Special emphasis is placed on a comprehensive definition of the term "ferroic". Novel forms of order, such as multiferroicity, are of particular interest. Their exploration and the material functionalities derived from these are a central theme in our Department.

Objective

Ferromagnetism is known to humankind for 2500 years, but there are many other forms of spontaneously ordered states in nature that wait to be explored. One of these is ferroelectricity, the spontaneous electric order of a materials, which rapidly gains importance in science and technology. It is the aim of this course to learn what actually defines a state as ferroic, what forms of ordering are known or newly proposed, and what kind of materials and functionalities are related to ferroic materials. We also explore the transition from order to disorder, which is fluent and offers materials properties that are not found in the fully ordered or disordered state.

It is an equally important goal that attendees learn to work critically and creatively with the "unfinished knowledge" of a "hot" research field that is in continuous and rapid development. Realizing that scientific results are not eternally true, but need to be constantly challenged and revised if necessary is very important in becoming a researcher working at the forefront of science.

Content

The power of symmetry analysis, aspects of crystallography and group theory, definition and concept of ferroic order, Forms of ferroic order in nature, domains and domain walls, multiferroics and magnetoelectric correlations, dynamical processes and functionalities in ferroic materials, the transition from order to disorder, thermodynamics of such transitions and associated material properties, tour through the Laboratory for Multifunctional Ferroic Materials.

Lecture notes

There is no actual script because one of the main goals of this lecture is to work critically and creatively with the "unfinished knowledge" of a "hot" research field that is in continuous and rapid development. It is important that attendees of the lecture form their own view of this field rather than following the filtered and biased view presented in a script.

Literature

V. K. Wadhawan, Introduction to Ferroic Materials, (Gordon and Breach 2000)

M. Fiebig, Nonlinear Optics on Ferroic Materials, (Wiley 2023)

R. R. Birss, Symmetry and Magnetism, (North Holland 1966)


Prerequisites / notice

Knowledge of the physics of materials, as provided by the ETH Zurich B.S. curriculum in Materials Science. Interdisciplinary or Physics students are also welcome. This lecture is on a "hot" research field that is in continuous and rapid development, so students are encouraged to provide continuous feedback so that the topics covered by the lecture can be constantly adopted. The lecture can only be as good as the constructive/critical feedback that is received.

Competencies

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<th>Subject-specific Competencies</th>
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<td>Problem-solving</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Self-awareness and Self-reflection</td>
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327-2210-00L Thin Films Technology - From Fundamentals to Oxide Electronics

Objective

In this course students will obtain an overarching view on thin film deposition techniques with a focus on epitaxial deposition processes. The main learning objectives are:

- Identification of most relevant deposition technique for a given application.
- Understanding of growth mechanism and growth modes.
- Understanding strategies for engineering the functionalities of the films using the deposition process.
- Selection of the most appropriate characterization technique.
- Understanding device concepts and fundamental limits in the technology relevant ultra-thin limit.
- Assessing the relevance of scientific literature dealing with complex oxide thin films.

Content

A lab visit will be organized and students will participate to the design of thin films with atomic precision.

General description of the leading deposition routes including physical and chemical vapor deposition techniques (PVD and CVD) as well as so called "wet techniques" (e.g. spin coating and spray pyrolysis).

Growth modes and processes.

Part of the course discusses vacuum technologies.

Fundamental characterization techniques for application-relevant thin films as well as state of the art approaches for in situ and ex-situ determination of the structural, chemical and ferroic (ferromagnetic and ferroelectric) properties of films: (XRD for thin films, RHEED, EDX, scanning probe microscopy techniques, laser-optical characterization and many more)

Epitaxy for the advanced design and characterization of high quality thin films for energy efficient oxide electronics.

Types of ferroic order, multiferroics, multifunctional oxide materials, epitaxial strain related effects, oxide thin film based devices and examples.

Regular discussions on preselected scientific literature and mini-seminars will be organized.
This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics. The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- 2 x 45 min will be covered by Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, who will present how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone

End of semester exam

Micro/Nanotechnology and Microfluidics for Biomedical Applications

Abstract
This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Objective
The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

Content
Mostly formal lectures (2 x 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology, colloidal stability, protein corona and cellular effects, lung- particles interactions: two disease scenarios and their molecular mechanism, gastric – particles interactions: intendent and unintendent particle exposure via food, skin – particles interactions: body care products and their influence on skin physiology, intravenous injection: colloidal stability, protein corona and cellular effects, micro- / Nanoplastics and development of a safety research plan, and an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing, liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics.

Competencies
Subject-specific Competencies
- Concepts and Theories
  - assessed
- Techniques and Technologies
  - assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - assessed
- Media and Digital Technologies
  - fostered
- Problem-solving
  - assessed
- Project Management
  - fostered

Social Competencies
- Communication
  - fostered
- Cooperation and Teamwork
  - fostered
- Customer Orientation
  - fostered
- Leadership and Responsibility
  - fostered
- Self-presentation and Social Influence
  - fostered
- Sensitivity to Diversity
  - fostered
- Negotiation
  - fostered

Personal Competencies
- Adaptability and Flexibility
  - fostered
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - fostered
- Self-awareness and Self-reflection
  - assessed
- Self-direction and Self-management
  - assessed

Nanostructured Materials Safety

Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.

Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.

Content
Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily live. These customized nanomaterials provides extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials.

The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications and intravenous injections as well as it will provide impulses for safer material designs.

Structure of the planned lecture (2 x 45 min)
1. Introduction: the principles of nanotoxicology
2. Lung- particles interactions: two disease scenarios and their molecular mechanism
3. GI – particles interactions: intendent and unintendent particle exposure via food
4. Skin – particles interactions: body care products and their influence on skin physiology
5. Intravenous injection: colloidal stability, protein corona and cellular effects
6. Micro- / Nanoplastics and development of a safety research plan
7. End of semester exam
### 402-0317-00L  Semiconductor Materials: Fundamentals and Fabrication

**W** 6 credits  2V+1U  S. Schön, W. Wegscheider

#### Abstract
This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

#### Objective
Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

#### Content
1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

#### Lecture notes
https://moodle-app2.let.ethz.ch/course/view.php?id=23113

#### Competencies
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- **Method-specific Competencies**
  - Analytical Competencies: fostered
  - Decision-making: fostered
  - Problem-solving: fostered
  - Project Management: fostered
- **Social Competencies**
  - Communication: fostered
  - Cooperation and Teamwork: fostered
  - Self-presentation and Social Influence: fostered

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### 402-0402-00L  Ultrafast Laser Physics

**W** 10 credits  3V+2U  L. P. Gallmann

#### Abstract
Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.

#### Objective
Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.
Content

This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

Prerequisites / notice

Prerequisites: Basic knowledge of quantum electronics (e.g., 402-0275-00L Quantenelektronik).

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed
assessed

402-0442-00L Quantum Optics 10 credits 3V+2U A. Imamoglu

Abstract

This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

Objective

The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.

Content

This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics that are covered include:

- coherence properties of light
- quantum nature of light: statistics and non-classical states of light
- light matter interaction: density matrix formalism and Bloch equations
- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

Lecture notes

Selected book chapters will be distributed.

Literature

Text-books:

G. Grynberg, A. Aspect and C. Fabre, Introduction to Quantum Optics
R. Loudon, The Quantum Theory of Light
Atomic Physics, Christopher J. Foot
Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
C. Cohen-Tannoudji et al., Atom-Photon-Interactions
M. Scully and M.S. Zubairy, Quantum Optics
Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics
### 402-0448-01L Quantum Information Processing I: Concepts

**W 5 credits 2V+1U J. Renes**

**Abstract**
The course covers the key concepts and formalism of quantum information processing. Topics include quantum algorithms, quantum error correction, quantum cryptography, and quantum metrology, with an emphasis on the power of quantum information processing beyond that of classical information processing. The formalism of quantum states, measurements, and channels is developed in detail.

**Objective**
By the end of the course students are able to explain the basic mathematical formalism of quantum mechanics and apply it to quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

**Content**
The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum circuits, quantum algorithms (Shor, Grover, Deutsch-Josza,...), stabilizer-based quantum error correction, fault-tolerant designs, the BB84 quantum key distribution protocol, and simple methods of quantum metrology.

**Lecture notes**
Will be provided.

**Literature**
Quantum Computation and Quantum Information
Michael Nielsen and Isaac Chuang
Cambridge University Press

**Prerequisites / notice**
A good understanding of finite dimensional linear algebra is recommended.

### Competencies

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<th>Competencies</th>
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<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
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### 402-0448-02L Quantum Information Processing II: Implementations

**W 5 credits 2V+1U A. Wallraff, J.-C. Besse**

**Abstract**

**Objective**
Throughout the past 20 years the realm of quantum physics has entered the domain of information technology in more and more prominent ways. Enormous progress in the physical sciences and in engineering and technology has allowed us to build novel types of information processors based on the concepts of quantum physics. In these processors information is stored in the quantum state of physical systems forming quantum bits (qubits). The interaction between qubits is controlled and the resulting states are read out on the level of single quanta in order to process information. Realizing such challenging tasks is believed to allow constructing an information processor much more powerful than a classical computer. This task is taken on by academic labs, startups and major industry. The aim of this class is to give a thorough introduction to physical implementations pursued in current research for realizing quantum information processors. The field of quantum information science is one of the fastest growing and most active domains of research in modern physics.

**Content**
Introduction to experimental systems for quantum information processing (QIP).
- Quantum bits
- Coherent Control
- Measurement
- Decoherence
- QIP with - Ions
- Superconducting Circuits
- Photons
- NMR
- Rydberg atoms
- NV-centers
- Quantum dots

**Lecture notes**
Course material be made available at www.qudev.ethz.ch and on the Moodle platform for the course. More details to follow.

**Literature**
Quantum Computation and Quantum Information
Michael Nielsen and Isaac Chuang
Cambridge University Press

**Prerequisites / notice**
The class will be taught in English language.

Basic knowledge of concepts of quantum physics and quantum systems, e.g from courses such as Physics III, Quantum Mechanics I and II or courses on topics such as atomic physics, solid state physics, quantum electronics are considered helpful.

More information on this class can be found on the web site www.qudev.ethz.ch
402-0464-00L  Light-Matter Interaction in Semiconductors: Physics and Applications

W  8 credits  2V+2U  T. Smolenski, A. Dikopol'tsev

Abstract
The course presents fundamental aspects of light-matter interaction in semiconductor materials, from basic research topics to opto-electronic devices.

Objective
The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these materials, enabled numerous applications as well as the realization of new physical concepts. In this course, we will learn the principles of light-matter interaction in semiconductors for single and multiple particle excitations, and cover opto-electronic applications based on these principles. We will study systems that include quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

Content
Electronic states in III-V materials and quantum structures, optical transitions, excitons and polaritons, novel two dimensional semiconductors, spin-orbit interaction, magneto-optics and opto-electronic devices.

Prerequisites / notice
Prerequisites: Quantum Mechanics II, Introduction to Solid State Physics, Quantum Electronics

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Social Competencies
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking

402-0465-58L  Intersubband Optoelectronics

W  6 credits  2V+1U  G. Scalari, J. Faist

Abstract
Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of semiconductors. Because of its inherent tailorability, this system can be seen as the "ultimate quantum designer's material".

Objective
The goal of this lecture is to explore both the rich physics as well as the application of these system for sources and detectors. In fact, devices based on intersubband transitions are now unlocking large area of the electromagnetic spectrum.

Content
The lecture will treat the following chapters:
- Introduction: intersubband optoelectronics as an example of quantum engineering
- Technological aspects
- Electronic states in semiconductor quantum wells
- Intersubband absorption and scattering processes
- Mid-IR and THz ISB Detectors
- Mid-infrared and THz photonics: waveguides, resonators, metamaterials
- Quantum Cascade lasers:
  - Mid-IR QCLs
  - THZ QCLs (direct and non-linear generation)
  - Further electronic confinement: interlevel Qdot transitions and magnetic field effects
  - Strong light-matter coupling in Mid-IR and THz range

Lecture notes
The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Literature
- E. Rosencher and B. Vinter, Optoelectronics, Cambridge Univ. Press
- G. Bastard, Wave mechanics applied to semiconductor heterostructures, Halsted press

Prerequisites / notice
Requirements: A basic knowledge of solid-state physics and of quantum electronics.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Social Competencies
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking

402-0526-00L  Ultrafast Processes in Solids

W  6 credits  2V+1U  Y. M. Acremann

Abstract
Ultrafast processes in solids are of fundamental interest as well as relevant for modern technological applications. The dynamics of the lattice, the electron gas as well as the spin system of a solid are discussed. The focus is on time resolved experiments which provide insight into pico- and femtosecond dynamics.

Objective
After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview over state of the art experimental techniques used to study fast processes.

Content
1. Experimental techniques, an overview
   2. Dynamics of the electron gas
      2.1 First experiments on electron dynamics and lattice heating
      2.2 The finite lifetime of excited states
      2.3 Detection of lifetime effects
      2.4 Dynamical properties of reactions and adsorbents
   3. Dynamics of the lattice
      3.1 Phonons
      3.2 Non-thermal melting
   4. Dynamics of the spin system
      4.1 Laser induced ultrafast demagnetization
      4.2 Ultrafast spin currents generated by lasers
      4.3 Landau-Lifschitz-Dynamics
      4.4 Laser induced switching
   5. Correlated materials

Lecture notes
will be distributed

Literature
relevant publications will be cited

Prerequisites / notice
The lecture can also be followed by interested non-physics students as basic concepts will be introduced.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Critical Thinking
Introduction to Magnetism

W 6 credits 2V+1U A. Vindigni

Abstract
This course tackles the fundamental question of why only a few materials exhibit magnetism in Nature. The origin of atomic magnetic moments and the key mechanisms that govern their interactions are justified starting from fundamental principles. In addition, the influence of thermal fluctuations on magnetic ordering is discussed as well as the formalism to describe magnetic resonance phenomena.

Objective
By the end of this course, students will develop the ability to utilize quantum mechanics concepts to estimate the strength of atomic magnetic moments and understand their reciprocal interactions. They will gain proficiency in interpreting experimental measurements on model systems in terms of material composition and an appropriate, phenomenological spin Hamiltonian. For instance, students will be able to recognize whether the magnetic hysteresis observed in some samples arises from slow dynamics or from a phase transition. Lastly, they will be capable of interpreting the occurrence of abrupt transitions or the emergence of characteristic length scales as resulting from the interplay between competing interactions. Altogether, students will acquire the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

Content
The lecture “Introduction to Magnetism” aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only a few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what “being magnetic” means is essential to address this question properly. Theoretical concepts will be applied to a few selected nano-sized magnets, which will serve as clear reference systems.

Topics:
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetism in solids (mechanisms producing inter-atomic exchange interaction in solids, crystall field)
- Magnetic order at finite temperatures (Ising, XY, and Heisenberg models, low-dimensional magnetism)
- Spin precession and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)

Lecture notes
Learning material will be made available through Moodle and through the ETH JupyterHub.

Prerequisites / notice
Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism. Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

Semiconductor Nanostructures

W 6 credits 2V+1U T. M. Ihn

Abstract
The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

Objective
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:
1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. The Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

Content
1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

Lecture notes

In addition to the lecture notes, the following supplementary books can be recommended:

Prerequisites / notice
The course is suitable for all physics students, students of Quantum Engineering, and students of Micro- and Nanosystems beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitious students in the third year of Physics may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

Social Competencies
- Communication
- Self-presentation and Social Influence
- Sensitivity to Diversity

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 857 of 2667
Abstract
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. The following topics will be covered:
- DNP theory & instrumentation
- Microwave theory & technology
- Biological applications of solid-state DNP

Objective
The course aims at enabling students to understand the key theoretical points of DNP and to design DNP experiments. Students will be familiarized with the structure of the state-of-the-art DNP instrumentation. Students will be also informed about the technological challenges towards the development of advanced instrumentation for the future DNP experiments. A special focus will be given in the technology of microwave source.

Furthermore, students will become familiar with pulse sequences used in biomolecular applications and understand how they are constructed. Students will be able to identify the strengths and weaknesses of biomolecular DNP and how to design DNP experiments for biological applications including sample preparation and choice of NMR experiment and related parameters.

Content
The course is separated in three well separated parts.

The first part will cover DNP concept and mechanisms, while a special focus will be given in DNP instrumentation, such as MAS technology, and the NMR probe. Several details will be also presented on the development high field NMR magnet.

The second part of the course is dedicated to the microwave technology and theory. This part starts with an introduction of the two different types of microwave sources, such as the solid-state devices and vacuum tubes, which are extensively used in DNP and EPR spectroscopy. A special focus will be given to the vacuum tube's theory and technology. In this context, the Maxwell equations and the propagation of the transverse electric and transverse magnetic modes in circular waveguides will be taught. This material will be the basis for understanding the resonance theory and the fundamentals of the microwave's generation in vacuum tubes. Based on the theoretical background gained in the previous lectures it will be possible to understand the operation principle of the slow wave devices, such as Klystron, Traveling Wave Tube (TWT), Backward Wave Oscillator (BWO) and Surface Wave Structure (SWS), as well as, the fast wave devices, such as gyro-devices, Free Electron Laser, etc. Finally, some details on the structure of a real DNP gyrotroon will be presented.

The third part of the course will cover CPMAS and homonuclear and heteronuclear recoupling schemes and their use in correlation spectroscopy for structure and molecular interaction determination. Sample preparation with particular emphasis of glassing agents and their relationship to DNP enhancements will be discussed. Resolution under DNP including a discussion about inhomogeneous and homogeneous broadening at cryogenic temperatures. Methods for circumventing low resolution at cryogenic temperatures will be discussed including site specific isotop labeling, bio-orthogonal labeling and site specific radical labeling/targeting. Concepts around the role of spin diffusion in DNP, direct and indirect DNP paramagnetic broadening, longitudinal T1 and methyl quenching in biological NMR will also be discussed. These concepts will then be tied together through discussions of biomolecular applications of solid-state DNP including membrane proteins, in-cell DNP and viruses.

Lecture notes
A script which covers the topics will be accessible through the course Moodle

Prerequisites / notice
Prerequisite: A basic knowledge of Magnetic Resonance, e.g. as covered in the Lecture Physical Chemistry IV, or the book “Spin Dynamics” by Malcolm Levitt.
Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract

Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based microdevices and -systems and all related microfabrication processes.

Objective

Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various microdevices and systems.

Content

Introduction to microtechnology, semiconductors, and micro electro mechanical systems (MEMS)

- Fundamentals of semiconductors and band model
- Fundamentals of devices: transistor and diode.
- Silicon processing and fabrication steps
- Silicon crystal structure and manufacturing
- Thermal oxidation
- Doping via diffusion and ion implantation
- Photolithography
- Thin film deposition: dielectrics and metals
- Wet etching & bulk micromachining
- Dry etching & surface micromachining
- Microtechnological processing and fabrication sequence
- Optional: Packaging

Lecture notes

Handouts in English

Literature


Prerequisites / notice

Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

The information on the web can be updated until the beginning of the semester.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies

Social Competencies
- Communication

Personal Competencies
- Critical Thinking

Abstract

The lecture provides an overview on the behavior and effects of anthropogenic particles in the environment, covering engineered nanoparticles, micro/nanoplastics, tire wear, soot and pigments. The course will cover key concepts of particle behavior and analysis, fate in technical and natural systems, toxicity and environmental risk assessment and sustainability aspects and regulation.

Objective

- Successful application of knowledge gained in traditional disciplines of environmental sciences (e.g. biogeochemistry, environmental chemistry) to elucidate particle fate and behavior in the environment
- Identify key parameters that potentially influence the environmental fate and behavior of anthropogenic particles
- Get acquainted with the most common analytical tools for the quantification of anthropogenic particles in the environment
- Critical assessment of current state of research, including the sometimes controversial literature data

Content

- Definitions, particle types
- Particle behavior: colloidal behavior, transport, transformation
- Sources and release: Material flow modeling
- Fundamentals of particle analysis
- Release and emission
- Fate in the environment: water, soil, air
- Fate in technical systems: water treatment, waste incineration
- Uptake and toxicity of particles
- Environmental risk assessment
- Life cycle assessment

Lecture notes

Handouts will be provided

Literature

will be provided during lecture
Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Decision-making
Personal Competencies
Creative Thinking
Critical Thinking

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Soft Materials (MaP Doctoral School)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-0213-00L</td>
<td>Fluid Dynamics with the Lattice Boltzmann Method</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>I. Karlin</td>
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Abstract
The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Objective
Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.

Content
The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:
1. Background: Elements of statistical mechanics and kinetic theory: Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation; Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.


3. Hands on: Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations: Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow: Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods: Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
Lecture notes
Lecture notes on the theoretical parts of the course will be made available.
Selected original and review papers are provided for some of the lectures on advanced topics.
Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0524-00L | Continuum Mechanics I | W | 4 credits | 2V+1U | A. E. Ehret

Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective
After successful completion of the course students are able to
• explain basic theories for solving continuum mechanics problems
• proficiently apply these theories by solving application-related academic examples
• relate the theories and examples to real engineering applications and challenges
• distinguish between different mechanical behaviors of materials
• systematically select appropriate constitutive theories suitable to analyze and model these materials

Content
Anisotropic Elasticity, Linear Elastic and Linear Viscous Material Behavior, Viscoelasticity, Micro-Macro Modelling, Lamine Theory, Plasticity, Viscoplasticity, Examples of Engineering Applications, Comparison with Experiments

Lecture notes
yes
Bioelectronics and Biosensors

W 6 credits 2V+2U J. Vörös, M. F. Yanik

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content
Lecture topics:
1. Introduction
   Sources of bioelectronic signals
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics
In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed
Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

Adaptability and Flexibility fostered
Negotiation fostered

Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Surfaces and Interfaces I: Fundamentals, Analytics and Applications

W 6 credits 3G L. Isa, M. P. Heuberger

Extended course starting HS23. Old title: Surfaces, Interfaces and their Applications I. Students who obtained credit points for the old course cannot retake it.

Abstract
This course teaches the basics of surface and interface science and technology, including surface modifications and forces. It covers various analytical techniques to study surface and interface properties, and explores phenomena of applied relevance like friction, lubrication, phoresis, and wetting where surfaces play a crucial role.

Objective
Students are able to
- describe the physical and chemical properties of surfaces and interfaces.
- analyze and compare analytical tools for surfaces.
- choose and combine appropriate surface-analytical approaches for solving problems connected to applications.
- understand and explain the importance of surfaces and interfaces in a broad range of phenomena and applications.
Content
- Introduction to surfaces and interfaces
- Structure of surfaces over different length scales: from macroscopic roughness to atomic structure
- Surface modifications
- Adsorption and adsorption models
- Surface forces
- Basic physical concepts
- Thermodynamics of surfaces and interfaces
- Measurement of intermolecular and surface forces
- Dynamics and history effects
- Surface analytics: X-ray Photoemission Spectroscopy (XPS) – principles and modern developments
- Surface analytics: Secondary Ion Mass Spectroscopy (SIMS) and IR Spectroscopy – Principles and examples
- Atomic Force Microscopy (AFM): Principles and modes of operation
- Tribology: Adhesion, Friction and Lubrication
- Contact mechanics
- Micro and macroscale friction
- Boundary lubrication
- Wetting
- Contact angles
- Phoretic phenomena
- Electric double layer and electrophoresis
- Electro-osmosis
- Other types of phoresis
- Case studies

Lecture notes
- Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Literature
- Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Prerequisites / notice
- Chemistry: General undergraduate chemistry including basic chemical kinetics and thermodynamics
- Physics: General undergraduate physics including basic theory of interatomic and intermolecular forces, atomic and crystalline structure of materials and their mechanical and electronic properties

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Project Management
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Leadership and Responsibility
- Personal Competencies
  - Adaptable and Flexible
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics

327-1207-00L  Soft Materials Engineering and Characterization  W  5 credits  4G  J. Vermant, L. Isa

Abstract
In this course, we discuss engineering aspects of soft materials. First, we cover different classes of soft matter systems, e.g. suspensions, gels, emulsion and foams, and introduce scaling principles to design their structural, mechanical and functional properties. Second, we cover essential characterisation techniques to interrogate the structure-property relations in soft materials.

Objective
The learning goals of the course are to introduce the students to soft matter and its technological applications, to see how the structure-property relations depend on fundamental formulation properties and processing steps. Students should also be able to select a measurement technique to evaluate the properties.

Lecture notes
- Slides with text notes accompanying each slide are presented.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Project Management
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Leadership and Responsibility
- Personal Competencies
  - Adaptable and Flexible
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics


Abstract
This course explores the mechanisms that govern the adaptive functions of out-of-equilibrium systems in living organisms at the molecular scale and the microstructural design principles of biological materials at larger length scales. Throughout the course, we will also explore how these design principles can be incorporated into synthetic systems to improve targeted functions.

Objective
- By the end of this course, students will be able to explain how natural selection optimizes biological materials at the molecular and microstructural levels and how this optimization process has resulted in the emergence of biological design principles that fulfill essential functions for species’ survival.
- Students will gain the ability to analyze and integrate bio-inspired adaptive functions into synthetic material systems, as well as interpret the correlation between function, microstructure, and performance of biological and bio-inspired materials. Through engaging activities, students will also develop strategies to create bio-inspired solutions for typical engineering problems and predict the performance of bio-inspired materials.
This course is divided into two main blocks. The first block focuses on the primary molecular adaptations of living organisms, while the second block covers the fundamental microstructural design principles present in biological materials.

**Block I: Molecular Adaptations of Living Organisms and Creation of Adaptive Bio-inspired Materials**
- Temporal regulation in biological and bio-inspired molecular systems;
- Autonomous molecular structures and out-of-equilibrium systems;
- Molecular motion and work generation mechanisms in biological and bio-inspired systems;
- Sensing, adaptation, and communication in biological and bio-inspired material systems;

**Block II: Principles of Microstructural Design in Biological Materials and Their Synthetically Engineered Counterparts**
- Fundamentals of engineering in biological and bio-inspired materials;
- Replicating biological design principles in synthetic materials (structural, optical, surface properties, etc.);
- Bio-inspired design and systems (mechanical action and bio-inspiration in the built environment).

The course is mainly based on the references listed below. Additional references will be provided during the lectures.


**Competencies**

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Techniques and Technologies</td>
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<td>Cooperation and Teamwork</td>
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<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
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<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
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**Content**

- Polymerization is series of continuous organic transformation and connects small molecules. The course will give an overview of the following important polymerization procedures:
  - Modern Step-growth polymerization
  - Living Anionic polymerization
  - Group transfer polymerization (GTP)
  - Controlled catonic polymerization
  - Controlled radical polymerization
  - Coordination polymerization: Ziegler-Natta and Metalloocene catalysts
  - Olefin metathesis polymerization: ROMP, ADMET and cyclopolymerization
  - Synthesis of conjugated polymers based on transition metal catalysis
  - Complex macromolecules including brush and dendronized polymers

**Objective**

Students should be able to:
- Identify important polymerization procedures and types of polymerization.
- Predict reactivities of monomers based on the chemical structures.
- Devise synthetic pathways to produce a given polymer structure.
- Evaluate properties of macromolecules based on structure and synthesis method.
- Develop synthesis schemes for target structures and discuss potential applications of polymers.

**Prerequisites**

- Strong basic knowledge of Organic Chemistry.
- Any course on Introductory Polymer Chemistry such as “Advanced Building Blocks for Soft Materials” or “Introduction to Macromolecular Chemistry” or equivalent (bachelor level is also sufficient). Please discuss with the lecturer if one is not certain about the prerequisites.

**Lecture notes**

Copies of the slides will be made available for download before each lecture.

Lecture notes will be uploaded on Moodle.

**Literature**

Lecture notes will be given.
The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoeresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters.

- 2 x 45 min will be covered by Yuki Temiz, a master of Arduino programming and do-it-yourself electronics, who will present how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone.
### Biocompatible Materials 529-0004-01L

**Abstract**
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**
Handouts are deposited online (moodle).

**Literature**

*(available online via ETH library)*

**Handouts and references therin.*

### Classical Simulation of (Bio)Molecular Systems 529-0433-01L

**Abstract**
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Objective**
Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

**Content**
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Lecture notes**
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

**Literature**
See: www.csms.ethz.ch/education/CSBMS

**Prerequisites / notice**
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

**Competencies**
- Subject-specific Competencies: assessed
- Method-specific Competencies: assessed
- Personal Competencies: fostered

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### Advanced Physical Chemistry: Statistical Thermodynamics 529-0455-00L

**Abstract**
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

**Objective**
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

**Content**

**Lecture notes**
See homepage of the lecture.

**Literature**
See homepage of the lecture.

**Prerequisites / notice**
Chemical Thermodynamics, Reaction Kinetics, Molecular Quantum Mechanics and Spectroscopy; Mathematical Foundations (Analysis, Combinatorial Relations, Integral and Differential Calculus)

**Competencies**
- Subject-specific Competencies: assessed
- Method-specific Competencies: assessed
- Personal Competencies: fostered

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### Laser for Micro- and Nanostructuring 529-0465-00L

**Abstract**
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**
Handouts are deposited online (moodle).

**Literature**

*(available online via ETH library)*

**Handouts and references therin.*
Abstract

Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as micro lithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Objective

Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, e.g. non-optical lithographies, will be discussed together with industrial applications, such as micro lithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Content

Introduction to lasers, Overview of micro- and nanotechnology, micro lithography, photoresists: classical types and new developments, laser cutting and welding, laser cleaning, laser ablation, polymer ablation: designed polymers, lasers and surfaces, laser spectroscopy, laser chemical vapor deposition, pulsed laser deposition (PLD), special materials by PLD, alternative structuring methods.

Lecture notes

The script (a copy of the slides) will be handed out during the first lecture.

Literature

FSRM, CD-ROM: An Introduction to the World of Microsystems, Neuchatel.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Methods-specific Competencies

Techniques and Technologies assessed
Social Competencies

Decision-making fostered
Communication fostered
Decision-making fostered
Project Management fostered
Cooperation and Teamwork fostered
Media and Digital Technologies fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Sensitivity to Diversity fostered
Self-presentation and Social Influence fostered
Negotiation fostered
Self-awareness and Self-reflection fostered
Critical Thinking assessed
Adaptability and Flexibility fostered
Integrity and Work Ethics assessed
Self-direction and Self-management fostered

Autumn Semester 2024

529-0615-01L Biochemical and Polymer Reaction Engineering W 6 credits

P. Arosio, P. Fleckenstein

Objective


Content

The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post- treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

Lecture notes

Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html
Additional handout of slides will be provided during the lectures.

Literature

H.W. Blincch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

529-0837-01L Biomicrofluidic Engineering W 6 credits

A. de Mello

Objective

We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.
Specific topics covered in the course include, but are not limited to:

1. **Theoretical Concepts**
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. **Microfluidic Device Manufacture**
   Basic principles of conventional lithography of rigid materials, 'soft' lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. **Electrokinetics**
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. **Mass Transfer Phenomena**
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. **Heat Transfer Phenomena**
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. **Microfluidic Systems for Materials Synthesis**
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. **Point-of-Care Diagnostics**
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. **Microscale DNA Amplification**
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. **Small volume Molecular Detection**
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. **Droplets and Segmented Flows**
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. **Single Cell Analysis**
    Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

Lecture notes
Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

Literature
There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

Competencies

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>Analytical Competencies</th>
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<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
<th>Project Management</th>
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<tr>
<td>Method-specific Competencies</td>
<td>Conventional Lithography</td>
<td>Methods of Microfluidic Manufacture</td>
<td>Microscale Tools for Diagnostics</td>
<td>Point-of-Care Diagnostics</td>
<td>Microscale DNA Amplification</td>
<td>Small Volume Molecular Detection</td>
<td>Droplets and Segmented Flows</td>
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**Cellular Matters: Properties, Functions and Applications of Biomolecular Condensates**

The number of participants is limited to 30 and will only take place with a minimum of 6 participants.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Abstract
This Master level course delves into the emerging field of biomolecular condensates - membrane-less organelles in cells. Using interdisciplinary concepts from biology, chemistry, biophysics, and soft matter, we will explore the biological properties of these condensates, their functions in health and disease, and their potential as new biomimetic materials for various applications.
In the last decade, a novel type of cell compartments called biomolecular condensates has been discovered. This discovery is radically changing our understanding of the cell, its organization, and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less compartments, similar to emulsions.

This interdisciplinary course encompasses milestone works and cutting-edge research questions in the young field of biomolecular condensates, including their properties, functions, and applications. The course begins with a lecture series that introduces the topic of condensates to an interdisciplinary audience and provides a theoretical foundation for understanding current research questions in the field. The lecture series provide a basic understanding of the principles of colloid science applied to the aggregation of food materials based on proteins, polysaccharides, and lipids. Mixtures of such raw materials determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food. The underlyng colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Students will not only learn how to critically read and evaluate scientific literature but will also gain valuable experience in giving scientific presentations to an interdisciplinary audience. Each presentation will require an introduction, critical analysis of the results, and a discussion of their significance, allowing students to substantiate their statements with a critical mindset that considers the pros and cons of chosen approaches and methods, as well as any limitations or possible follow-up experiments. This process will enable students to ask relevant questions and actively participate in class discussions, further enhancing their scientific skills.

In preparing the presentations, students will have the unique opportunity to interact closely with each other and with the lecturers, who are internationally well-establishied experts, and receive guidance in selectin a topic for the final presentaton and supporting literature. At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Literature</th>
<th>Competencies</th>
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<tr>
<td>Lecture slides and some scripts will be provided.</td>
<td>No compulsory textbooks. Literature will be provided during the course</td>
<td>Subject-specific Competencies: Concepts and Theories</td>
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**752-2000-00L Food Materials Science**

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<th>Objective</th>
<th>Abstract</th>
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<tr>
<td>Students will be able to:</td>
<td>Principles of soft condensed matter applied to food polymers, surfactants and colloids</td>
<td>Subject-specific Competencies: Concepts and Theories</td>
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<tr>
<td>- Describe the fundamental physical principles ruling the self-assembly, aggregation, processing and structure-properties relationship in food systems constituted by polysaccharides (polymers), proteins (colloids) and lipids (surfactants).</td>
<td>- Assess and recommend the best set of parameters controlling structure in foods</td>
<td>Method-specific Competencies: Analytical Competencies</td>
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<tr>
<td>- Integrate physical and chemical principles to optimize food properties to meet specific requirements of defined food products</td>
<td>- Integrate physical and chemical principles to optimize food properties to meet specific requirements of defined food products</td>
<td>Problem-solving</td>
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**752-2314-00L Physics of Food Colloids**

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<tr>
<td>The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.</td>
<td>In Physics of Food Colloids the principles of colloid science will applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.</td>
<td>Subject-specific Competencies: Concepts and Theories</td>
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Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

Notes will be handed out during the lectures.

The course gives an introduction to structural glass design and related façade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.

The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements and structurally design them.

The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent façades.

Design exercises:

The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Design project:

The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

The lectures are based on lecture slides and handouts.
Literature

Recommended and supplementary literature:

Prerequisites / notice

Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies

- Communication

Personal Competencies

- Creative Thinking
- Critical Thinking

Lecture notes

Lecture notes see: http://www.concrete.ethz.ch

101-0127-00L Advanced Structural Concrete

Abstract

This course supplements the courses Structural Concrete I and II regarding the analysis and dimensioning of reinforced and prestressed concrete structures. It focuses on limit analysis methods for walls, beams, slabs and shells, particularly regarding their applicability to the safety assessment of existing structures and their computer-aided implementation.

Objective

Within this course, the students are able to:

- deepen their understanding of structural concrete models and apply them to general design problems, including the assessment of existing structures.
- enhance their knowledge about the load-deformation response of reinforced and prestressed concrete structures.
- identify and assess the limits of applicability of limit analysis methods.
- recognise the assumptions of models suitable for computer-aided structural design and use in a critical way structural concrete design software.
- evaluate the long-term behaviour and the behaviour under fire conditions of concrete structures.
- assess the behaviour of fibre reinforced concrete structures.

Content

Fundamentals (structural analysis, theorems of limit analysis, applicability of limit analysis methods); walls and beams (stress fields and strut-and-tie models, compatibility and deformation capacity, membrane elements with yield conditions and load-deformation behaviour, computer-aided structural design); slabs (equilibrium solutions, yield conditions, shear and punching shear, sustainability); long term effects; steel fibre reinforced concrete (mechanical behaviour, applications); fire behaviour.

Lecture notes

Lecture notes see: http://www.concrete.ethz.ch

Literature


Prerequisites / notice

Students are assumed to be proficient in the material taught in the following courses offered in the BSc in Civil Engineering at ETH Zurich (or have acquired equivalent knowledge elsewhere):

- Theory of structures I+II
- Structural Concrete I+II (incl. prestressed concrete)

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies

- Communication

Personal Competencies

- Creative Thinking
- Critical Thinking

101-0129-00L Non Destructive Evaluation & Rehabilitation of Existing Structures

Abstract

Introduction to non destructive evaluation tools and quantitative structural analyses and verifications for condition assessment of existing structures and subsequent decisions on their rehabilitation.

Objective

The goal is for students to familiarize themselves with the handling of assessment and rehabilitation of existing structures from the perspective of a consulting engineer, following a systematic approach as described in current codes and to further learn how to use new non destructive evaluation technologies.

Content

This course is organized in two main pillars. The first pillar describes the technologies that are available for non destructive evaluation of structures and delves into description of the principle of operation of such methods (e.g. wave propagation, acoustic emission analysis, tomography). The second pillar, overviews the current implementation of condition assessment processes in codes and standards.

Complementary to the topic of structural evaluation, the topic of interventions, rehabilitation and retrofitting of existing structures for different construction materials is next addressed.

Lecture notes

Lecture notes

Literature


Swiss Standards SIA 269, 269/1 to 269/7

SIA-Document D 0239 « Existing Structures – Introduction » (in German/French)

SIA-Document D 0239 « Existing Structures – Consolidation and Practice » (in German/French)

A. Costa, A. Arêde, H. Varum, Strengthening and Retrofitting of Existing Structures, Springer, 339p, 2018
The course slides serve as Script. These are openly available on: http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html

In Steel Structures III, students will deepen and expand their theoretical background and practical knowledge of the design and construction of steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. Students will learn how to solve complex structural engineering tasks in larger building projects, e.g. through the use and correct design of large-span slim-floor girders and ultra-slim-composite columns, or the use of glazing and cable structures as principal load-carrying components. They learn how steel structures behave under fire conditions and how they can be protected and designed accordingly. Finally, students learn about the fundamental aspects governing the design of specialty steel structures, such as thin-walled cold-formed sections, crane girders, masts and storage tanks.

The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

Steel Structures III provides in-depth theoretical background and practical knowledge on advanced design topics in steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. The course discusses the use and design of large-span slim-floor girders and ultra-slim-composite columns, as well as the use of glazing and cable structures as principal load-carrying components. The design of steel structures under elevated temperatures (fire conditions) is treated, as well as special topics of design for serviceability. In addition, fundamental concepts of the design of cold-formed steel framed structures are discussed. Finally, the course will give an overview on the design of specialty steel structures, such as crane girders, masts and storage tanks.

The course specifically covers the treatment of the following phenomena:
- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The course slides serve as Script. These are openly available on: http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html

Useful (optional) Reading:
Prerequisites /
notice
Prerequisites:
- 101-0158-01 Method of Finite Elements I (FS)
  - A good knowledge of Python is necessary for attending this course.

Competencies
Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Analytical Competencies
Problem-solving
Social Competencies: Cooperation and Teamwork
Personal Competencies: Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection

101-0167-01L Fibre Composite Materials in Structural Engineering W 3 credits 2G M. Motavalli
Abstract
1) Lamina and Laminate Theory
2) FRP Manufacturing and Testing Methods
3) Design and Application ofExternally Bonded Reinforcement to Concrete, Timber, and metallic Structures
4) FRP Reinforced Concrete, All FRP Structures
5) Measurement Techniques and Structural Health Monitoring
Objective
At the end of the course, you shall be able to
1) Design advanced FRP composites for your structures,
2) To consult owners and clients with necessray testing and SHM techniques for FRP structures,
3) Continue your education as a phd student in this field.

Content
Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring technologies. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

Lecture notes
Power Point Presentations available online at www.empa.ch/abt303

Literature
3) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019
4) SIA166 (2004) Klebebewehrungen (Externally bonded reinforcement), Schweizerischer Ingenieur- und Architektenverein SIA

Prerequisites /
notice
1) Laboratory Tours and Demonstrations: Empa Structural Engineering Laboratory including FRP Composites, Shape Memory Alloys, Timber Elements, Large Scale Testing of Structural Components
2) Working with Composite Materials in the Laboratory (application, testing, etc)

101-0527-10L Materials and Constructions W 4 credits 2G G. Habert, M. Posani
Abstract
Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Looking at material sourcing, properties and performance, as well as how they are integrated in the buildings (building envelope and detailing).
Choice of material is done out of sustainability concern. Comfort, moisture transfer and building physics with hygroscopic materials.

Objective
Special focus on regenerative materials: earth, bio-based and reuse
The students will acquire knowledge in the following fields:
- Fundamentals of material performance
- Introduction to durability problems of building facades

Materials for the building envelope:
- Overview of structural materials and systems: concrete, steel, stone, earth and wood and bamboo
- Insulating materials (bio-based vs conventional)

Assessment of materials and components behaviour and performance
Degradation risks connected to insulation and post-insulation
Aspects of sustainability and durability

Special focus on comfort, moisture transfer and building physics with hygroscopic materials will be done.

Content
Introduction
Sustainable cement and concrete
Earth construction
Stone
Steel
Bamboo
Timber construction
Building hyphic and conventional insulation
Bio-based insulation and degradation risks with insulation
Hygrothermal properties of building materials and dynamic numerical simulations
Efficiency and sustainability of modern window glazing

Course will have general lectures
+ hands on lab @home experiments
+ group project for implementation of regenerative materials.
Advances in Building Materials

W 4 credits 2G R. J. Flatt, I. Burgert

Abstract
The course on Advances in Building Materials provides an introductory overview of the needs and future of materials science in the building sector. Focus topics concern sustainability, durability, thermal insulation, coatings, sealants, adhesives, flame retardancy and the future perspective and developments of concrete and wood with regard to smart material development and ecological concerns.

Objective
In this course, the students will gain a broad overview of the use of materials in the building sector, with a particular focus on concrete and wood. Current limitations and in particular sustainability related challenges will be detailed with the objective of laying the grounds to discuss future developments anticipated in this field.

Content
This course for civil engineers lays the grounds in the specialization Materials and Mechanics and complements the second introductory course of the specialization on Numerical Mechanics of Materials. The course also addresses master students in Materials Science and other study programs interested in deepening their understanding of application-relevant properties of engineering materials and sustainability related challenges.

The following topics are covered:
1. Material selection
2. Materials and sustainability 1
3. Materials and sustainability 2
4. Recyclability
5. Material science of wood durability
6. Material science of concrete durability
7. Foams in construction and thermal insulation
8. Sealants and adhesives in construction
9. Coatings
10. Flame retardants
11. Future of wood – 1
12. Future of wood – 2
13. Future of concrete – 1
14. Future of concrete – 2

Lecture notes
Handouts will be provided for each lecture.

Computational Science Investigation for Material Mechanics

W 4 credits 2S D. Kammer, F. Wittel

Abstract
Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various material models.

Objective
Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can often only be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

Content
1 Introduction to (numeric) forensic engineering
2 The nature of engineering problems (governing equations)
3 Numerical recipes for dealing with non-linear problems
4 Multi-field problems (HTM)
5 Creep and relaxation
6 On the nature of failure - Physics of damage and fracture
7 Cracks and growth in structures (LEFM and beyond)
8 Damage and fracture in heterogeneous materials
9 Mechanics of fatigue
10 Student -Project presentation

Lecture notes
Will be provided during the lecture via moodle.

Literature
Will be provided during the lecture.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

Science and Engineering of Glass and Natural Stone in Construction

Does not take place this semester.
The course offers an overview of relevant practical issues and present technological challenges for glass and natural stones in constructions. Students gain a good knowledge of the basics of glasses and natural stones, their potential as engineering materials and learn to apply them in the design of civil engineering constructions and to evaluate concepts.

Glass is increasingly used in constructions to ease the construction process, as functional insulation barrier, even for structural applications of impressive size. While everyone has experienced the innovation potential of glass in the last decade, products from natural stone suffer from an unjustified traditional image that often originates from a lack of understanding of the material and its combination with other materials. Culturally important structures are often made from natural stone and their conservation demands an understanding of their deterioration mechanisms, the concepts of which can be applied to other civil engineering materials. Designers and engineers need the knowledge to reconcile materials and system behavior with the entire processing, handling, integration and life time in mind.

In this module students are provided with a broad fundamental as well as practice-oriented education on glass and natural stone in civil engineering applications. Present and future construction and building concepts demand for such materials with optimized properties. Based on the fundamentals from the Bachelor course in materials by the end of this module, you should be able to:

- recognize and choose specific applications from the broad overview you were provided with,
- relate processing technologies to typical products and building applications and recognize (and explain typical damage related to wrong material choice or application,
- explain the nature of glassy and crystalline materials and interpret their physical behavior against this background,
- explain the major deterioration mechanisms in natural stone and how this relates to durability,
- analyze material combinations and appraise their application in future products as well as integration in existing constructions,
- summarize with appropriate guidance publications on a related topic in an oral presentation and short report.

### Content

Lecture 1: An introduction to science and engineering of glass and natural stone in construction (FW/TW)

Lecture 2: Glass chemistry including historical development of glass composition, use of raw materials, melts, chemical stability and corrosion. (FW)

Lecture 3: Geology and mineralogy of stones used in construction. Formation processes, chemistry, crystal structure. (TW)

Lecture 4: Microscopic models for glassy materials. Physics of vitrification. From microscopic physical models to thermodynamics, rheology and mechanics of glassy materials. (FW)

Lecture 5: Stone properties and behavior: microstructure, density, porosity, mechanical properties (TW)

Lecture 6: Glass physics: Optical properties (transmission, reflection, emission, refraction, polarization and birefringence, testing methods); Mechanical properties (density, thermal, mechanical, electric properties, glass testing) (FW)

Lecture 7: Stone properties and durability: transport, moisture and thermal cycling (TW)

Lecture 8: Forming and processing of glass: (plate and molded glass, drawing, slumping, profiling etc.; Processing: Cutting, mechanical processing, tempering, gluing, bending, laminating of glass Surface treatments: coating, sputtering, enameling, printing, etching, chemical pre-stressing.) (FW)

Lecture 9: Durability: Salt crystallization, freezing, biodeterioration (TW)

Lecture 10: Glass products for civil engineering applications: (Molded glasses, fiber glass, foam glass, plate glass); construction glass (insulation glass, structural glass, protective glass, intelligent glass, codes); (FW)

Lecture 11: Conservation: Consolidation, cleaning, and other treatments (TW).

Lecture 12: Glass in constructions. (modelling, application and regulation, typical damage in glass) (FW)

Lecture 13: Student presentations; exam questions (FW/TW)

Lab 1: Durability of natural stone (FW/TW)

Lab 2: Fracture of glass (FW/TW)

**Literature**

Werkstoffe II script (download via the IFB homepage). Rest will be handed out in the lectures.

Werkstoffe I/II of the bachelor studies or equivalent introductory materials lecture.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Assessed</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Critical Thinking</td>
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<td>Self-direction and Self-management</td>
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**101-0659-01L Durability and Maintenance of Reinforced Concrete**

We look at the durability of reinforced concrete structures, covering common deterioration processes such as reinforcement corrosion, frost damage, ASR, etc. The course spans the range from fundamental mechanisms to aspects of engineering practice. New methods and materials for preventative measures, condition assessment and repair techniques are treated. Examples from real cases are shown.
Objective
After this course you will have profound understanding about:

- the different mechanisms of deterioration of concrete structures, in particular reinforcement corrosion
- the relevant parameters affecting durability of reinforced concrete (cover depth, concrete quality, moisture, etc.)

Furthermore, you will know:

- current engineering approaches for durability design (according to standards) and their limitations
- refined models for enhanced durability design and service life predictions
- preventive measures to improve durability (e.g. stainless steel reinforcement, concrete surface coatings, etc.)
- the particular durability challenges with post-tensioned structures and ways to overcome them (electrically isolated tendons)
- methods for inspection and condition assessment of existing, ageing structures (including non-destructive techniques and monitoring with sensors)
- repair methods for deteriorated concrete structures such as conventional repair and electrochemical methods (in particular cathodic protection)
- possible future problems for durability that may arise with modern materials and construction technologies

Content
- Socio-economic challenges related to ageing infrastructures
- Degradation mechanisms for concrete: sulphate attack, ASR, frost attack.
- Inspection and condition assessment: Chloride analyses, carbonation depth, etc. Non-destructive tests, particularly potential mapping to detect corrosion. New developments (for example, monitoring with sensors).
- Stainless steel as reinforcing steel for concrete: Different types of stainless steels. Coupling with black reinforcing steel. Examples of application. Life-cycle-costs.
- Modern materials and construction technologies: Discussion of expected implications for the durability of structures today and in the future.

Excursion:

- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Lecture notes
The course is based on the book


Slides of the lectures will be distributed in advance

Prerequisites / notice
Special handouts and reprints for particular topics will be distributed

Form of teaching:
The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

Report:
Each student will work on a small case study and deliver a report during the semester. The report will be graded.

Excursion:

- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management assessed

101-0677-00L Concrete Technology W 2 credits 2G F. Nägele, G. Martinola, T. Wangler

Abstract
Opportunities and limitations of concrete technology, Commodities and leading edge specialties.

Objective
Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.
Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as: self compacting concrete, fiber reinforced concrete, fast setting concrete
- the role of sustainability in concrete technology
- new research in digital fabrication with concrete

Lecture notes

Slides provided for download.

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Problem-solving assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Personal Competencies

Adaptability and Flexibility fostered

Creative Thinking assessed

Critical Thinking assessed

151-0353-00L Mechanics of Composite Materials W 4 credits 2V+1U G. Pappas

Abstract

The courses treats aspects related to elastic behavior of unidirectional and multidirectional laminates, micromechanics, failure and damage analysis, analysis and design of composite structures. The focus is on laminated fiber-reinforced polymer composites.

Objective

The objective is to introduce the basic concept of composite materials and provide a thorough understanding of the mechanical response of such materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

Content

The course is addressing following topics:

- Introduction
- Elastic anisotropy
- Micromechanics & Homogenization
- Classical Laminate Theory (CLT)
- Strength, failure and damage analysis
- Thin ply composite shells & effects of material non-linearity
- Analysis and design of composite structures

Lecture notes

Script, handouts, exercises and additional material are available in PDF-format on the moodle page of the lecture.

Literature

The lecture material is covered by a script/lecture notes compiled by CMASLab and further literature is referenced therein.

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making assessed

Media and Digital Technologies fostered

Problem-solving assessed

Project Management fostered

Social Competencies

Communication fostered

Cooperation and Teamwork fostered

Customer Orientation fostered

Leadership and Responsibility fostered

Self-presentation and Social Influence fostered

Sensitivity to Diversity fostered

Negotiation fostered

Personal Competencies

Adaptability and Flexibility fostered

Creative Thinking assessed

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-awareness and Self-reflection assessed

Self-direction and Self-management fostered

151-0524-00L Continuum Mechanics I W 4 credits 2V+1U A. E. Ehret

Abstract

The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective

After successful completion of the course students are able to:

- explain basic theories for solving continuum mechanics problems
- proficiently apply these theories by solving application-related academic examples
- relate the theories and examples to real engineering applications and challenges
- distinguish between different mechanical behaviors of materials
- systematically select appropriate constitutive theories suitable to analyze and model these materials

Content

Anisotropic Elasticity, Linear Elastic and Linear Viscous Material Behavior, Viscoelasticity, Micro-Macro Modelling, Laminate Theory, Plasticity, Viscoplasticity, Examples of Engineering Applications, Comparison with Experiments

Lecture notes

yes
L. De Lorenzis

Analytical Competencies
Topics include temperature and strain rate dependent elasto-plasticity, dynamic brittle and ductile fracture; impulse transfer, impact and wave propagation in solids; computational aspects of material model implementation; simulation of dynamic failure of structures; procedures in solid mechanics.

Method-specific Competencies
- Analytical Competencies: Decision-making, Problem-solving
- Media and Digital Technologies: assessed

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: fostered

Lecture notes / Literature
Various books will be recommended pertaining to the topics covered.

Prerequisites / notice
Course in continuum mechanics (mandatory), finite element method (recommended)

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T. Tancogne-Dejean

Nonlinear FEA
Does not take place this semester.

Abstract
The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

Objective
To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.

Content
1. Introduction; various sources of nonlinearities and implications for FEA.

Lecture notes / Literature
Lecture notes will be provided. However, students are encouraged to take their own notes.

Prerequisites / notice
Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

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E. Hosseini

Metal Additive Manufacturing - Mechanical Integrity

Abstract
An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

Objective
The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using commercial analysis tools (e.g. ABAQUS) for simulation of the MAM process.

Content
- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (stainless steel, Ti6Al4V, Inconel 718),
- Design for additive manufacturing,
- Artificial intelligence for AM

Exercise sessions use ABAQUS for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. Students can install the packages on their own systems.

Lecture notes / Literature
Handouts of the presented slides.

No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).

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E. Holtz

Nonlinear FEA

Abstract
The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

Objective
To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.

Content
1. Introduction; various sources of nonlinearities and implications for FEA.

Lecture notes / Literature
Lecture notes will be provided. However, students are encouraged to take their own notes.

Prerequisites / notice
Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

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E. Hosseini

Metal Additive Manufacturing - Mechanical Integrity

Abstract
An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

Objective
The main objectives of this lecture are:
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- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using commercial analysis tools (e.g. ABAQUS) for simulation of the MAM process.

Content
- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (stainless steel, Ti6Al4V, Inconel 718),
- Design for additive manufacturing,
- Artificial intelligence for AM

Exercise sessions use ABAQUS for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. Students can install the packages on their own systems.

Lecture notes / Literature
Handouts of the presented slides.

No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).
Adaptive Materials for Structural Applications

W 4 credits 3G A. Bergamini

Abstract
Adaptive materials offer appealing ways to extend the design space of structures by introducing time-variable properties into them. In this course, the physical working principles of selected adaptive materials are analyzed and simple models for describing their behavior are presented. Some applications are illustrated, also with laboratory experiments where possible.

Objective
The study of adaptive materials covers topics that range from chemistry to theoretical mechanics.

Content
The basic workable definitions of adaptive materials, their properties and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.

Analytical tools and energy based considerations will provide the students with effective instruments for understanding adaptive materials and assess their performance when integrated in structures or when arranged in particular fashions.

151-8015-00L Moisture Transport in Porous Media

W 3 credits 2G J. Carmeliet, A. Kubilay, A. Rubin, D. A. Strebel

Abstract
Moisture transport and related degradation processes in porous materials Theory of moisture transport in porous materials

Objective
- Basic knowledge of moisture transport and related degradation processes in porous materials
- Application of knowledge to moisture transport in cracked materials, drying of porous materials and microclimate in urban street canyons

Content
1. Introduction
Moisture damage: problem statement, durability
Applications: building materials, soil science, geoscience

2. Moisture transport: theory and application
Description of moisture transport
Determination of moisture transport properties
Exercises on moisture transport properties

3. Special topics
Liquid transport in cracked materials, Drying of porous materials, Microclimate in urban street canyons

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Literature
All material is provided online via Moodle.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

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227-0377-10L Physics of Failure and Reliability of Electronic Devices and Systems

W 3 credits 2V I. Shorubalko, M. Held

Abstract
Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective
Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content
Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Lecture notes
Comprehensive copy of transparencies

Literature

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327-2103-00L Composites and Hybrids: From Design to Application

W 5 credits 3V+1U F. J. Clemens, B. Weisse, A. Winistörfer

Abstract
Composites/hybrids are heterogeneous materials consisting of two or more bonded components, and it is possible to tailor material properties for certain applications. Typically, The components retain their structure and properties, but the properties of the composite are a combination of the properties of its components.

Objective
In this course you will get an inside to lightweight material with high strength, materials that are resistive against abrasion, ceramics with damage tolerance behavior, composites with bioactive, bioreabsorbable, piezoresistive and -electric properties. Enables materials scientists to design composite/hybrid materials for different applications. The course will comprise a balance of lectures, exercises and laboratory classes.

Content
Introduction and basic concepts on biomedical composites and smart composites/hybrids with sensing and actuation properties; production and properties of composites reinforced with particles, whiskers, short or long fibers; selection criteria, case studies and applications, future perspectives.

1. Structural composites (polymer-, metal- and ceramic matrix composites)
   1.1. Introduction and historical background
   1.2. Components: Matrix and reinforcement materials
   1.3. Types of composites and mechanisms of reinforcement
   1.4. Production processes
   1.5. Physical and chemical properties
   1.6. Applications

2. Biomedical Composites
   2.1. Introduction and historical background
   2.2. Components: Metals&alloys, natural/synthetic polymers, bioceramics
   2.3. Types of biocomposites
   2.4. Production processes
   2.5. Properties
   2.6. Applications

3. Functional Composites (Sensors and Actuators)
   3.1. Introduction and historical background
   3.2. Components: Matrix and functional filler material
   3.3. Types of composites
   3.4. Production processes
   3.5. Properties
   3.6. Applications

Lecture notes
We will work with handouts

Literature
Biomedical composites, J. Paulo Davim (Ed.), De Gruyter (2014)
Bioresorbable polymers for biomedical applications – from fundamentals to translational medicine, G. Perale, J. Hilborn (Eds), Woodhead Publishing (2017)
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
- Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Literature
- Academic Press

Sustainable & Bioinspired Materials (MaP Doctoral School)

Number Title Type ECTS Hours Lecturers
101-0527-10L Materials and Constructions W 4 credits 2G G. Habert, M. Posani

Abstract
Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Looking at material sourcing, properties and performance, as well as how they are integrated in the buildings (building envelope and detailing).

Objective
Special focus on regenerative materials: earth, bio-based and reuse
The students will acquire knowledge in the following fields:
- Fundamentals of material performance
- Introduction to durability problems of building facades
- Materials for the building envelope:
  - Overview of structural materials and systems: concrete, steel, stone, earth, wood and bamboo
  - Insulating materials (bio-based vs conventional)
- Assessment of materials and components behaviour and performance
- Degradation risks connected to insulation and post-insulation
- Aspects of sustainability and durability
- Special focus on comfort, moisture transfer and building physics with hygroscopic materials will be done.

Content
- Sustainable cement and concrete
- Earth construction
- Stone
- Steel
- Bamboo
- Timber construction
- Building physic and conventional insulation
- Bio-based insulation and degradation risks with insulation
- Hygrothermal properties of building materials and dynamic numerical simulations
- Efficiency and sustainability of modern window glazing

Course will have general lectures
- hands on lab @home experiments
- group project for implementation of regenerative materials.
### Wood Structure and Function

**Course Code:** 101-0637-10L  
**Title:** Wood Structure and Function  
**Teacher:** I. Burgert, G. von Arx

#### Abstract
The course Wood structure and function conveys basic knowledge on the microstructure of softwoods and hardwoods as well as general and species-specific relationships between growth processes, wood properties, and wood function in the living tree. In an introduction to wood anatomy, the general structural features of softwoods and hardwoods will be explained and factors of diversity and variability will be discussed. A specific focus is laid on common central European tree species with relevance in the wood sector, which will be studied in macro-and microstructural investigations. In the following, relationships between wood structure, properties and function in the living tree will be in the focus of the lectures. Topics covered are water transport, trends in wood anatomy within trees, environmental impact on wood anatomy, wood defects and their causes, tools to study wood properties over time, secondary changes in wood, and tree biomechanics.

#### Objective
- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and models, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

#### Content
- Allocation (multoutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

#### Lecture notes
No script. Lecture slides and literature will be made available on Moodle.

#### Literature
Literature will be made available on Moodle.

#### Prerequisites / notice
Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

### Advanced Environmental Assessments

**Course Code:** 102-0317-00L  
**Title:** Advanced Environmental Assessments  
**Teacher:** S. Pfister, A. Kim

#### Abstract
This course deepens students' knowledge of the environmental assessment methodologies and their various applications. In particular, students completing the course should have the

- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and models, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

#### Objective
- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and models, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

#### Content
- Allocation (multoutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

#### Lecture notes
No script. Lecture slides and literature will be made available on Moodle.

#### Literature
Literature will be made available on Moodle.

#### Prerequisites / notice
Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

### Acoustics in Fluid Media: From Robotics to Additive Manufacturing

**Course Code:** 151-0509-00L  
**Title:** Acoustics in Fluid Media: From Robotics to Additive Manufacturing  
**Teacher:** D. Ahmed

#### Abstract
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

#### Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

#### Content
- Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices

#### Lecture notes

#### Literature

### General Notice
- The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence assessed
Sensitivity to Diversity fostered

Personal Competencies
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-direction and Self-management assessed

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151-0524-00L Continuum Mechanics I W 4 credits 2V+1U A. E. Ehret

Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective
After successful completion of the course students are able to
• explain basic theories for solving continuum mechanics problems
• proficiently apply these theories by solving application-related academic examples
• relate the theories and examples to real engineering applications and challenges
• distinguish between different mechanical behaviors of materials
• systematically select appropriate constitutive theories suitable to analyze and model these materials

Content
Anisotropic Elasticity, Linear Elastic and Linear Viscous Material Behavior, Viscoelasticity, Micro-Macro Modelling, Laminate Theory, Plasticity, Viscoplasticity, Examples of Engineering Applications, Comparison with Experiments

Lecture notes
yes

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

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227-0393-10L Bioelectronics and Biosensors W 6 credits 2V+2U J. Vörös, M. F. Yanik

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content
Lecture topics:
1. Introduction
2. Sources of bioelectronic signals
3-4. Membrane and Transport
3. Action potential and Hodgkin-Huxley
5. Measuring bioelectronic signals
6. Detection and Noise
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics
10. In vivo stimulation and recording
11. Functional electric stimulation
12. In vivo electrophysiology
13. Optical recording and control of neurons (optogenetics)
14. Measuring biochemical signals
15. Measuring neurons optically, fundamentals of optical microscopy
16. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
## Concepts and Theories

### Fostered

### Assessed

### Analytical Competencies

### Communication

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Concepts and Theories</td>
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<td>Project Management</td>
<td>Negotiation</td>
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### Literature


### Prerequisites

- No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>327-1101-00L</td>
<td>Biomineralization</td>
<td>W 2V</td>
<td>K.-H. Ernst</td>
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</table>

### Abstract

The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

### Objective

The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

### Content

Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

1. 1. Introduction and overview
2. 2. Biominerals and their functions
3. 3. Chemical control of biomineralization
4. 4. Control of morphology: Organic templates and additives
5. 5. Modern methods of investigation of BM
6. 6. BM in matrices: bone and nacre
7. 7. Vertebrate teeth
8. 8. Invertebrate teeth
9. 9. BM within vesicles: calcite of coccoliths
10. 10. Silica
11. 11. Iron storage and mineralization

### Prerequisites

No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

### Lecture notes

Script with more than 600 pages with many illustrations will be distributed free of charge.

### Literature

- 3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.), *Biomineralization*, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

### Notice

- Replicating biological design principles in synthetic materials (structural, optical, surface properties, etc.);
- Fundamental principles of engineering in biological and bio-inspired materials;
- Bio-inspired design and systems (mechanical actuation and bio-inspiration in the built environment).
The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. The course is mainly based on the references listed below. Additional references will be provided during the lectures.

Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to increased fracture risk as a result, leading to devastating diseases such as osteoporosis. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and
different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

The learning objectives include
1. advanced knowledge of the state-of-the-art in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

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7. encouragement of critical thinking and creating an environment for independent and self-directed studying.
Micro/Nanotechnology and Microfluidics for Biomedical Applications

376-1351-00L

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Communication

Abstract
This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beans for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Objective
The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

Content
Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and opticalbiosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- 2 × 45 min will be covered by Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, who will present how to make 2$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone

Prerequisites / notice
- A laptop is needed with the below Systems Requirements:
  - Memory: 16 GB
  - Processor: 3rd gen i7
  - DirectX® 11.0 compliant AMD Radeon/NVIDIA® GeForce® card with 2 GB RAM
  - Storage: 15 GB
  - Mac computer can be used by pre-installing Windows through bootcamp (older Macs) or Parallels Desktop (14th trial license, 35 CHF license purchasable in the IT shop of ETH).

Biocompatible Materials

376-1714-00L

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.
### Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the material surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

### Objective
Getting insight into actual areas and problems of biomechanics.

### Abstract
Current topics in biomechanics presented by speakers from academia and industry.

### Literature

Handouts and references therin.

### 529-0615-01L Biochemical and Polymer Reaction Engineering

<table>
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<tr>
<th>W</th>
<th>6 credits</th>
<th>3G</th>
<th>P. Arosio, P. Fleckenstein</th>
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<tbody>
<tr>
<td>Content</td>
<td>We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes, Kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.</td>
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<tr>
<td>Lecture notes</td>
<td>Scripts are available on the web page of the Arosio-group: <a href="http://www.arosio-group.ethz.ch/education.html">http://www.arosio-group.ethz.ch/education.html</a></td>
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<tr>
<td></td>
<td>H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995</td>
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### 529-0837-01L Biomicrofluidic Engineering

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<th>A. de Mello</th>
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<tr>
<td>Objective</td>
<td>Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-µ environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.</td>
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<tr>
<td>Abstract</td>
<td>We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.</td>
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<td>A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an &quot;academic-style&quot; research article and a &quot;conference-style&quot; oral presentation. Course grades will be evaluated through both a written exam and the project grade.</td>
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Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, ‘soft’ lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrophoretic Devices
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small volume Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

Lecture notes
   There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

Literature
   Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

Competencies
   Subject-specific Competencies
   - Concepts and Theories: assessed
   - Techniques and Technologies: assessed

   Method-specific Competencies
   - Analytical Competencies: assessed
   - Decision-making: assessed
   - Media and Digital Technologies: assessed
   - Problem-solving: assessed
   - Project Management: assessed

   Social Competencies
   - Communication: assessed
   - Cooperation and Teamwork: assessed

   Personal Competencies
   - Adaptability and Flexibility: assessed
   - Creative Thinking: assessed
   - Critical Thinking: assessed

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 887 of 2667
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on fostered

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration assessed, K. M. Berg, A. Lauria,

Creative Thinking
Transferable Skills Course II (1-3 days)
P. A. Fischer

Lecturers

The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

**752-3105-00L**  
**Physiology Guided Food Structure and Process Design**

- **Objective**
  - A sound understanding of physiological implications of food design will allow to shape new products, which feature health as well as environmental benefits and on the other side do not compromise on organoleptic qualities, formulation and manufacturing, and quality and safety. The course links the physiological driven requirements with food structure design and subsequent engineering steps. 

- **Content**
  
  Chapter 1: Introduction - The need for physiology guided structure and process design in the context of personalized nutrition (Peter Fischer)
  
  Chapter 2: Food Oral Processing: the impact of food oral breakdown on sensory perception (Marine Devezeaux de Lavergne)
  
  Chapter 3: Chewing and swallowing across the lifespan, from infants to elderly (Marine Devezeaux de Lavergne)
  
  Chapter 4: Perception physiology in humans and other species (Benöt von der Weid)
  
  Chapter 5: Biophysics of food digestion & how it can be exploited in the development of strategies for delivery (Timothy J. Wooster)
  
  Chapter 6: Numerical and experimental modelling of the intestinal system (Peter Fischer)

- **Lecture notes**
  
  Lecture notes are available at Moodle

- **Competencies**
  
  Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
  
  Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
  
  Social Competencies: Communication
  
  Personal Competencies: Critical Thinking, Integrity and Work Ethics

**► Transferable Skills**

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<td>Ethics and Scientific Integrity for Doctoral Students (MaP Doctoral School)</td>
<td>W</td>
<td>1</td>
<td>2U</td>
<td>M. Trassin, K. M. Berg, A. Lauria, S. Stepanow</td>
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</table>

**Abstract**

This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a discipline specific context.

**Objective**

Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

**Content**

Part I

The self-paced e-learning course consists of 5 modules:

1. Ethics: Introduction to moral theory (with emphasis on practical guidance regarding decision making)
2. Ethics in Scientific Research: Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).
3. Collecting Resources: A variety of tools and resources that help identify ethical issues are presented and explained
4. Setting up a Strategy: Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).
5. Making Decisions: Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II

The second, face-to-face part of this course focuses on discipline-specific aspects of Materials, Processes and Manufacturing Technologies. It provides an interactive learning environment. Participants get to apply their knowledge, and they are encouraged to reflect on ethical problems and critically discuss them with fellow doctoral students.

**Prerequisites / notice**

For doctoral students only

<table>
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<tr>
<th>900-0100-DRL</th>
<th>Transferable Skills Course I (1-3 days)</th>
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**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**900-0101-DRL**  
**Transferable Skills Course II (1-3 days)**

- **Objective**
  
  Only for doctoral students.

  Please select your doctoral thesis supervisor as a lecturer
and prove your participation with the appropriate certificate.

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Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective  
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Educational Science for Teaching Diploma and TC  
Language Courses ETH/UZH: see Science in Perspective  

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**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week.

**900-0109-DRL**
Transferable Skills Course I (1 week, with Poster or Talk)
Only for doctoral students.

*Abstract*
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

*Objective*
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

**W 3 credits 6S Lecturers**

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**900-0110-DRL**
Transferable Skills Course II (1 week, with Poster or Talk)
Only for doctoral students.

*Abstract*
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

*Objective*
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

**W 3 credits 6S Lecturers**

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**900-0111-DRL**
Transferable Skills Course III (1 week, with Poster or Talk)
Only for doctoral students.

*Abstract*
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

*Objective*
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

**W 3 credits 6S Lecturers**

---

**900-0112-DRL**
Participation in Commission I (min 1 year)
Only for doctoral students.

*Abstract*
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

*Objective*
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**W 1 credit 2P Lecturers**

---

**900-0113-DRL**
Participation in Commission II (min 1 year)
Only for doctoral students.

*Abstract*
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

*Objective*
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**W 1 credit 2P Lecturers**

---

**900-0114-DRL**
Member of Executive Board (min 1 year)
Only for doctoral students.

*Abstract*
Active participation in the presidium or executive board of a university group for at least 1 year.

*Objective*
Active participation in the presidium or executive board of a university group for at least 1 year.

**W 2 credits 4P Lecturers**

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**Integration into Scientific Community**

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*Abstract*
Participation in summer or winter schools with a maximum duration of 3 days.

*Objective*
Participation in summer or winter schools with a maximum duration of 3 days.

| 900-0151-DRL | Summer School II (1-3 days) | W    | 1 credit | 2K   | Lecturers |

*Abstract*
Participation in summer or winter schools with a maximum duration of 3 days.

*Objective*
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Objective
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Abstract
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Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

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**Doctorate Materials Science - Key for Type**

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<td>W</td>
<td>Eligible for credits</td>
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<td>E</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

**Key for Hours**

- V: lecture
- G: lecture with exercise
- U: exercise
- S: seminar
- K: colloquium
- P: practical/laboratory course
- A: independent project
- D: diploma thesis
- R: revision course / private study

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Subject Specialisation

The list of courses (together with the allocated credit points) eligible for doctoral students is published each semester in the newsletter of the ZGSM. [More information](https://zgsm.math.uzh.ch/index.php?id=861&keySemId=47&key1=0).

### Graduate School

[Official website of the Zurich Graduate School in Mathematics](http://www.zgsm.ch)

### Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
401-5741-DRL | Floer Homology of Three-Manifolds and Applications to Low Dimensional Topology | W | 2 credits | 2V | not available
Abstract: Doctoral students of I-Math (UZH) need to send an email to Jessica Bolsinger (info@zgsm.ch) with the course number. The email should have the subject „Graduate course registration (ETH)“. Nachdiplom lecture

401-5743-DRL | Dispersive Equations and Wave Turbulence Theory | W | 2 credits | 2V | not available
Abstract: Doctoral students of I-Math (UZH) need to send an email to Jessica Bolsinger (info@zgsm.ch) with the course number. The email should have the subject „Graduate course registration (ETH)“. Nachdiplom lecture

401-5001-DRL | Foundations of D-MATH Doctoral Studies I | W | 3 credits | 5V | Lecturers
Prerequisites / notice

401-5002-DRL | Foundations of D-MATH Doctoral Studies II | W | 3 credits | 5V | Lecturers

### Colloquia

### Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
401-5000-00L | Zurich Colloquium in Mathematics | E- | 0 credits | A. Bandeira, S. Mishra, R. Pandharipande, University lecturers

401-5990-00L | Zurich Graduate Colloquium | E- | 0 credits | 0.5K | University lecturers, further speakers
Abstract: The Graduate Colloquium is an informal seminar aimed at graduate students and postdocs whose purpose is to provide a forum for communicating one's interests and thoughts in mathematics.

401-4530-00L | Geometry Graduate Colloquium | E- | 0 credits | 1K | Speakers

401-5110-00L | Number Theory Seminar | E- | 0 credits | 1K | Ö. Imamoglu, E. Kowalski, G. Wüstholz, S. Zerbes

401-5140-11L | Algebraic Geometry and Moduli Seminar | E- | 0 credits | 2K | R. Pandharipande

401-5530-00L | Geometry Seminar | E- | 0 credits | 1K | M. Burger, M. Einsiedler, U. Lang, further speakers

401-5350-00L | Analysis Seminar | E- | 0 credits | 1K | F. Da Lio, N. Hungerbühler, T. Ilmanen, K. Kindler, L. Kobel-Keller, S. Mayboroda, J. Serra, University lecturers

401-5370-00L | Ergodic Theory and Dynamical Systems | E- | 0 credits | 1K | M. Akka Ginosar, M. Einsiedler, University lecturers

401-5580-00L | Symplectic Geometry Seminar | E- | 0 credits | 1K | P. Biran, A. Cannas da Silva

401-5650-00L | Zurich Colloquium in Applied and Computational Mathematics | E- | 0 credits | 1K | R. Alaifari, H. Ammari, R. Hiptmair, S. Mishra, C. Schwab

401-5330-00L | Talks in Mathematical Physics | E- | 0 credits | 1K | M. Gaboridiel, G. M. Graf, P. Hintz, T. H. Willwacher

401-5600-00L | Seminar on Stochastic Processes | E- | 0 credits | 1K | A. Nikeghbali

401-5620-00L | Research Seminar on Statistics | E- | 0 credits | 1K | Y. Chen, N. Meinshausen, J. Peters, J. Ziegel, A. Bandeira, R. Furrer, T. Hothorn

Abstract
About 3 talks on applied statistics.

Objective
See how statistical methods are applied in practice.

Content
There will be about 3 talks on how statistical methods are applied in practice.

Prerequisites / notice
This is no lecture. There is no exam and no credit points will be awarded. The current program can be found on the web: http://stat.ethz.ch/events/zukost
Course language is English or German and may depend on the speaker.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Conceptual and Theoretical fostered</th>
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<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Decision-making fostered</td>
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<tr>
<td>Problem-solving</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking fostered</td>
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401-5680-00L Foundations of Data Science Seminar
Abstract
Research colloquium

401-5660-00L DACO Seminar
Abstract
Research colloquium

401-5910-00L Talks in Financial and Insurance Mathematics
Abstract
Research colloquium

252-4202-00L Seminar in Theoretical Computer Science
Abstract
Presentation of recent publications in theoretical computer science, including results by diploma, masters and doctoral candidates.

Objectives
The goal is to introduce students to current research, and to enable them to read, understand, and present scientific papers. This seminar takes place as part of the joint research seminar of several theory groups. Intended participation is for students with excellent performance only. Formal restriction is: prior successful participation in a master level seminar in theoretical computer science.

Transferable Skills

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</table>
900-0112-DRL  Participation in Commission I (min 1 year)  W  1 credit  2P  Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective  Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL  Participation in Commission II (min 1 year)  W  1 credit  2P  Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective  Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL  Member of Executive Board (min 1 year)  W  2 credits  4P  Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Active participation in the presidium or executive board of a university group for at least 1 year.

Objective  Active participation in the presidium or executive board of a university group for at least 1 year.

401-5010-00L  Ethics and Scientific Integrity for Doctoral Students at D-MATH  W  1 credit  1R  E. Kowalski, not available

Part I on Moodle
The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only.

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

Competencies

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Decision-making</td>
<td>Problem-solving</td>
<td>Integrity and Work Ethics</td>
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Educational Science for Teaching Diploma and TC
Language Courses ETH/UZH: see Science in Perspective

Integration into Scientific Community

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<tr>
<th>Number</th>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 896 of 2667
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<thead>
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<th>Code</th>
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Only for doctoral students.

Abstract Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

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Doctorate Mathematics - Key for Type

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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>W-</td>
<td>Recommended, not eligible for credits</td>
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Key for Hours

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<td>G</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
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<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 998 of 2667
# Subject Specialisation

Please note that this is an INCOMPLETE list of courses.

<table>
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<tr>
<th>Number</th>
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<tr>
<td>402-0317-00L</td>
<td><strong>Semiconductor Materials: Fundamentals and Fabrication</strong></td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>S. Schön, W. Wegscheider</td>
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**Abstract**

This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

**Objective**

Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

**Content**

1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

**Lecture notes**

https://moodle-app2.let.ethz.ch/course/view.php?id=23113

**Prerequisites / notice**

The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Communication

**Social Competencies**

- Self-presentation and Social Influence

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<thead>
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<tr>
<td>402-0442-00L</td>
<td><strong>Quantum Optics</strong></td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>A. Imamoglu</td>
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**Abstract**

This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

**Objective**

The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.

**Content**

- coherence properties of light
- quantum nature of light: statistics and non-classical states of light
- light matter interaction: density matrix formalism and Bloch equations
- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

**Lecture notes**

Selected book chapters will be distributed.

**Literature**

- Text-books:
  - G. Gryenberg, A. Aspect and C. Fabre, Introduction to Quantum Optics
  - R. Loudon, The Quantum Theory of Light
  - Atomic Physics, Christopher J. Foot
  - Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
  - C. Cohen-Tannoudji et al., Atom-Photon-Interactions
  - M. Scully and M.S. Zubairy, Quantum Optics
  - Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

**Social Competencies**

- Communication
- Cooperation and Teamwork

**Personal Competencies**

- Creative Thinking
- Critical Thinking

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<tr>
<td>402-0442-05L</td>
<td><strong>Advanced Topics in Quantum Optics</strong></td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>T. Esslinger</td>
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The lecture will cover current topics and papers in the wider field of quantum optics in an interactive format. Several papers will be presented by the students in the style of a journal club. Selected papers will be contrasted and their strengths and weaknesses discussed by the students in panel discussions. Recent papers on arXiv.org will be discussed and referee reports referee reports.

We will select topical fields in quantum optics and quantum science and discuss recently published work.

The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum

Quantum Computation and Quantum Information


Subject-specific Competencies

Throughout the past 20 years the realm of quantum physics has entered the domain of information technology in more and more prominent ways. Enormous progress in the physical sciences and in engineering and technology has allowed us to build novel types of information processors based on the concepts of quantum physics. In these processors information is stored in the quantum state of physical systems forming quantum bits (qubits). The interaction between qubits is controlled and the resulting states are read out on the level of single quanta in order to process information. Realizing such challenging tasks is believed to allow constructing an information processor much more powerful than a classical computer. This task is taken on by academic labs, startups and major industry. The aim of this class is to give a thorough introduction to physical implementations pursued in current research for realizing quantum information processors. The field of quantum information science is one of the fastest growing and most active domains of research in modern physics.

402-0448-01L Quantum Information Processing I: Concepts

This theory part QIP I together with the experimental part 402-0448-02L QIP II (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in Physics.

The course covers the key concepts and formalism of quantum information processing. Topics include quantum algorithms, quantum error correction, quantum cryptography, and quantum metrology, with an emphasis on the power of quantum information processing beyond that of classical information processing. The formalism of quantum states, measurements, and channels is developed in detail.

By the end of the course students are able to explain the basic mathematical formalism of quantum mechanics and apply it to quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum circuits, quantum algorithms (Shor, Grover, Deutsch-Jozsa,...), stabilizer-based quantum error correction, fault-tolerant designs, the BB84 quantum key distribution protocol, and simple methods of quantum metrology.

Lecture notes

Will be provided.

Literature

Quantum Computation and Quantum Information

Michael Nielsen and Isaac Chuang

Cambridge University Press

Prerequisites / notice

A good understanding of finite dimensional linear algebra is recommended.

402-0448-02L Quantum Information Processing II: Implementations

This experimental part QIP II together with the theory part 402-0448-01L QIP I (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in Physics.


Throughout the past 20 years the realm of quantum physics has entered the domain of information technology in more and more prominent ways. Enormous progress in the physical sciences and in engineering and technology has allowed us to build novel types of information processors based on the concepts of quantum physics. In these processors information is stored in the quantum state of physical systems forming quantum bits (qubits). The interaction between qubits is controlled and the resulting states are read out on the level of single quanta in order to process information. Realizing such challenging tasks is believed to allow constructing an information processor much more powerful than a classical computer. This task is taken on by academic labs, startups and major industry. The aim of this class is to give a thorough introduction to physical implementations pursued in current research for realizing quantum information processors. The field of quantum information science is one of the fastest growing and most active domains of research in modern physics.
Introduction to experimental systems for quantum information processing (QIP).
- Quantum bits
- Coherent Control
- Measurement
- Decoherence
- QIP with - Ions
- Superconducting Circuits
- Photons
- NMR
- Rydberg atoms
- NV-centers
- Quantum dots

Course material be made available at www.qudev.ethz.ch and on the Moodle platform for the course. More details to follow.

The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.
- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

The course presents fundamental aspects of light-matter interaction in semiconductor materials, from basic research topics to opto-electronic devices.

The main body of the course will present the rich physics and applications of semiconductor devices based on intersubband transitions are now unlocking large area of the electromagnetic spectrum.

The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these materials, enabled numerous applications as well as the realization of new physical concepts. In this course, we will learn the principles of light-matter interaction in semiconductors for single and multiple particle excitations, and cover opto-electronic applications based on these principles.

We will study systems that include quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials. Because of its inherent taylorability, this system can be seen as the "ultimate quantum designer's material". Numerous applications as well as the realization of new physical concepts. In this course, we will learn the principles of light-matter interaction in semiconductors for single and multiple particle excitations, and cover opto-electronic applications based on these principles.

The class will be taught in English language.

Basic knowledge of concepts of quantum physics and quantum systems, e.g. from courses such as Physics III, Quantum Mechanics I and II or courses on topics such as atomic physics, solid state physics, quantum electronics are considered helpful.

More information on this class can be found on the web site www.qudev.ethz.ch
402-0468-15L  Nanomaterials for Photonic Devices  W  6 credits  2V+1U R. Grange, E. Bailly, R. Chapman, V. Falcone, A. Morandi

Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, photonic integrated circuits, ordered and disordered structures...). It starts with concepts of light-matter interactions, fabrication and characterization, the description of the properties and the state-of-the-art applications and devices.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.

Content
1. Introduction to nanophotonics
2. Wave physics for nanophotonics
3. Characterization of nanomaterials
4. Semiconductors
5. Nonlinear crystals
6. Photonic integrated circuits
7. Optical quantum devices
8. Plasmonics
9. Metasurfaces
10. Graphene & 2D Materials
11. Nanocomposites

Lecture notes
Slides and book chapter will be available for downloading

Literature
References will be given during the lecture

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Social Competencies
Self-presentation and Social Influence fostered

Personal Competencies
Creative Thinking fostered

402-0475-00L  Terahertz Science and Applications  W  5 credits  2V+1U E. Abreu

Abstract
The Terahertz (THz) range (0.1 – 10 THz), lies between the infrared and microwave spectral regions and has become accessible in the past few years. This new capability has had great impact in scientific research, and has led to technological advances and to the development of a variety of applications and devices. This course provides an introduction to THz science, technology and applications.

Objective
The goal of this course is to enable students to determine whether a THz solution can be applied to a particular scientific or technological problem. Armed with the fundamentals of THz science and of current THz technologies, covered in this introductory course, students will be able to weigh the capabilities, advantages and limitations of THz tools to address topics ranging from phonons in solid state systems and molecular vibrations in solutions to medical imaging and wireless communications.

Lecture notes
Will be distributed via moodle.

Literature
Yun-Shik Lee, Principles of Terahertz Science and Technology, Springer 2009

Prerequisites / notice
Basic knowledge in physics, especially in electromagnetism, is required. No formal prerequisites.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Leadership and Responsibility fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

402-0492-00L  Experimental Techniques in Quantum and Electro-...  W  6 credits  2V+1U
Creative Thinking

This course tackles the fundamental question of why only a few materials exhibit magnetism in Nature. The origin of atomic magnetic moments and the key mechanisms that govern their interactions are justified starting from fundamental principles. In addition, the influence of thermal fluctuations on magnetic ordering is discussed as well as the formalism to describe magnetic resonance phenomena. Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

Electronic and Magnetic Properties of Solids

Fostered

After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview over state of the art experimental techniques used to study fast processes.

Lecture notes

Relevant publications will be cited

Prerequisites

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Competencies

Subject-specific Competencies

Concepts and Theories

assessed

Methods-specific Competencies

Analytical Competencies

assessed

Decision-making

fostered

Problem-solving

assessed

Project Management

fostered

Social Competencies

Communication

assessed

Personal Competencies

Creative Thinking

fostered

Critical Thinking

fostered

Optics

We will cover experimental issues in making measurements in modern physics experiments. The primary challenge in any measurement is achieving good signal to noise. We will cover areas such as optical propagation, electronics, noise limits and feedback control. Methods for stabilizing frequencies and intensities of laser systems will also be described.

In addition, the lecture “Introduction to Magnetism” aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only a few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what “being magnetic” means is essential to address this question properly. Theoretical concepts will be applied to a few selected nano-sized magnets, which will serve as clean reference systems. Examples from a modern quantum information laboratory will be discussed and illustrated through active devices in the lecture.

402-0526-00L

Ultrafast Processes in Solids

W

6 credits

2V+1U

Y. M. Acremann

Ultrafast processes in solids are of fundamental interest as well as relevant for modern technological applications. The dynamics of the lattice, the electron gas as well as the spin system of a solid are discussed. The focus is on time resolved experiments which provide insight into pico- and femtosecond dynamics.

By the end of this course students will develop the ability to utilize quantum mechanics concepts to estimate the strength of atomic magnetic moments and understand their reciprocal interactions. They will gain proficiency in interpreting experimental measurements on model systems in terms of material composition and an appropriate, phenomenological spin Hamiltonian. For instance, students will be able to recognize whether the magnetic hysteresis observed in some samples arises from slow dynamics or from a phase transition. Lastly, they will be capable of interpreting the occurrence of abrupt transitions or the emergence of characteristic length scales as resulting from the interplay between competing interactions. Altogether, students will acquire the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

4.4 Laser induced switching

4.3 Landau-Lifschitz-Dynamics

4.2 Ultrafast spin currents generated by lasers

4.1 Laser induced ultrafast demagnetization

4. Dynamics of the spin system

3.2 Non-thermal melting

3.1 Phonons

3. Dynamics of the lattice

2.1 First experiments on electron dynamics and lattice heating

2.2 The finite lifetime of excited states

2.3 Detection of lifetime effects

2.4 Dynamical properties of reactions and adsorbents

Lecture notes

Relevant publications will be cited

Prerequisites / notice

The lecture can also be followed by interested non-physics students as basic concepts will be introduced.

402-0535-00L

Introduction to Magnetism

W

6 credits

3G

A. Vindigni

This course tackles the fundamental question of why only a few materials exhibit magnetism in Nature. The origin of atomic magnetic moments and the key mechanisms that govern their interactions are justified starting from fundamental principles. In addition, the influence of thermal fluctuations on magnetic ordering is discussed as well as the formalism to describe magnetic resonance phenomena.

4.4 Laser induced switching

4.3 Landau-Lifschitz-Dynamics

4.2 Ultrafast spin currents generated by lasers

4.1 Laser induced ultrafast demagnetization

4. Dynamics of the spin system

3.2 Non-thermal melting

3.1 Phonons

3. Dynamics of the lattice

2.1 First experiments on electron dynamics and lattice heating

2.2 The finite lifetime of excited states

2.3 Detection of lifetime effects

2.4 Dynamical properties of reactions and adsorbents

Lecture notes

Learning material will be made available through Moodle and through the ETH JupyterHub.

Prerequisites / notice

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.
This course gives an introduction into Accelerator Mass Spectrometry (AMS), the most sensitive method for measuring long-lived radionuclides found in nature. Basic methodology, the latest developments, and special examples from a wide range of applications will be discussed.

Objective

The seminar provides the participants an overview about newest trends and developments of accelerator mass spectrometry (AMS) and related applications. In their talks and subsequent discussions the participants learn intensively about the newest trends in the field of AMS and thus attaining a broad knowledge on both, the physical principles and the applications of AMS, which goes far beyond the horizon of their own studies.

Abstract

The seminar is aimed at all students who, during their studies, are confronted with age determination methods based on long-living radionuclides found in nature. Basic methodology, the latest developments, and special examples from a wide range of applications will be discussed.

Method-specific Competencies

- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Personal Competencies

- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

Competencies

- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

References

7. Coulomb blockade and quantum dots
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

Prerequisites

The lecture is suitable for all physics students, students of Quantum Engineering, and students of Micro- and Nanosystems beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitioned students in the third year of Physics may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

Table of Contents

- The integer quantum Hall effect
- Conductance quantization in quantum point contacts
- the Aharonov-Bohm effect
- Coulomb blockade in quantum dots

Lecture notes

Content

Introduction into the physics of ion matter interaction: ion stopping, ion scattering and charge exchange.

Ion optics and ion acceleration.

Mass separation, molecular destruction and isobar separation.

Ion detection and identification.

The measurement methods for all the important radionuclides and the interpretation of their results are discussed on a few examples from the application:

- 14C – radiocarbon dating and environmental studies
- 10Be, 26Al, 36Cl – cosmogenic dating and ice core research
- 129I, 236U, actinides – anthropogenic tracers in the environment
- 14C, 41Ca – biomedical studies
- 60Fe, 244Pu – astrophysics

Alternative methods: ICP-MS, RIMS, ATTA

A visit to the Tandem accelerator and AMS facilities at ETH Hönggerberg is organized as part of lectures and exercises.

Abstract

Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate on flagship experiments which have significantly improved our understanding of particle physics today, concentrating mainly on precision experiments with neutrons, muons and exotic atoms.

Objective

You will be able to present and discuss:
- the principle of the experiments
- the underlying technique and methods
- the context and the impact of these experiments on particle physics

Content

Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one directly searches for new particles at energies up to the TeV range. In a complementary way, low energy particle physics indirectly probes the existence of such particles and provides constraints for "new physics", making use of high precision and high intensities.

Besides the sensitivity to effects related with new physics (e.g. lepton flavor violation, symmetry violations, CPT tests, search for electric dipole moments, new low mass exchange bosons etc.), low energy physics provides the best test of QED (electron g-2), the best tests of bound-state QED (atomic physics and exotic atoms), precise determinations of fundamental constants, information about the CKM matrix, precise information on the weak and strong force even in the non-perturbative regime etc.

Starting from a general introduction on high intensity/high precision particle physics and the main characteristics of muons and neutrons and their production, we will then focus on the discussion of fundamental problems and ground-breaking experiments:

- search for rare decays and charged lepton flavor violation
- electric dipole moments and CP violation
- spectroscopy of exotic atoms and symmetries of the standard model
- what atomic physics can do for particle physics and vice versa
- neutron decay and primordial nucleosynthesis
- atomic clock
- Penning traps
- Ramsey spectroscopy
- Spin manipulation
- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling....

Literature

- Golub, Richardson & Lamoreaux: "Ultra-Cold Neutrons"
- Rauch & Werner: "Neutron Interferometry"
- Carlile & Willis: "Experimental Neutron Scattering"
- Byrne: "Neutrons, Nuclei and Matter"
- Klapdor-Kleingrothaus: "Non Accelerator Particle Physics"

Prerequisites / notice

Einführung in die Kern- und Teilchenphysik / Introduction to Nuclear- and Particle-Physics
Content

Topics covered include:

- Review of probability theory:
  - Independence, joint and conditional probabilities
  - Univariate and multivariate probability distributions
  - Change of variables
- Bayesian statistics:
  - Bayes’ theorem
  - Priors
  - Bayesian reasoning
  - Posterior distributions, model checking, and model comparison Tools for statistical inference:
  - Various sampling methods, such as Markov chain Monte Carlo (Metropolis Hastings, slice sampling, Hamiltonian Monte Carlo) and nested sampling
  - Simulation-based inference
  - PCA, bootstrap
  - Gaussian processes and Gaussian random fields
  - Machine learning and probabilistic programming

The lectures are accompanied with code examples, both to illustrate the covered topics and to demonstrate how the theoretical concepts can be implemented in practical computational inference problems.

The students complete a project on a statistical analysis, using the tools covered in the course.

Prerequisites / notice

Prior knowledge of probability theory and statistics would be useful but not required. Since most of the course makes use of computational methods, some knowledge of scientific computing with Python (e.g. numpy, scipy) will be assumed.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Leadership and Responsibility

Personal Competencies

- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

402-0767-00L Neutrino Physics

Abstract

Theoretical basis and selected experiments to determine the properties of neutrinos and their interactions (mass, spin, helicity, chirality, oscillations, charge-parity violation, interactions with leptons and quarks) and implications on physics beyond the Standard Model of elementary particles as well as on Cosmology.

Objective

Critically analyze and elaborate the neutrino production and detection techniques. Analyze the phenomenology of neutrino oscillations and its implication on the physics Beyond the Standard Model of particles. Derive the main concepts of the theory of neutrino masses within and beyond the Standard Model of particles and analyze the experimental techniques related to the measurement of the neutrino masses. Describe the role of neutrinos in Cosmology and make connections with current and future neutrino experiments. Review the experimental configurations and analyze the challenges in searches for leptonic Charge-Parity symmetry violation and the measurement of the neutrino mass hierarchy.

Content

1. Introduction to Neutrinos and Neutrino Sources;
2. Neutrino Detectors
3. Neutrino Interactions
4. Neutrino Oscillations
5. Nature of Neutrino masses
6. Neutrinos in Cosmology
7. Search for leptonic Charge Parity violation and precision measurement of the neutrino oscillation probability

Literature

A. Rubbia, “Phenomenology of Particle Physics”, Cambridge University Press


D.O. Caldwell, Current Aspects of Neutrino Physics, Springer.


K. Zuber, “Neutrino Physics” CRC Press 2020

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Personl Competencies

- Creative Thinking
- Critical Thinking

402-0831-67L Advanced Topics in General Relativity and Gravitational Waves (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: PHYS29

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html
The aim of this lecture is to discuss some advanced topics in general relativity, which are useful to understand the present research activities in the field. A list of possible topics is given below. A basic knowledge of general relativity is required (ideally having followed the lecture on General Relativity). The course is particularly suited for master and PhD students.

This might be also useful in view of doing afterwards a master thesis in the field of general relativity.

Possible content:
- General relativistic stellar structure equations (Neutron stars)
- Tetrad formalism
- Spinors in GR
- Klein-Gordon & Dirac eqs. in GR
- Thermodynamics of black holes and Hawking radiation
- Topics in gravitational waves: GW generation by PN sources, GW from elliptic, hyperbolic binaries
- Tests of the equivalence principle

Subject-specific Competencies
- Is to be able to read and understand the original literature and the presently published papers in the field of the discussed advanced topics.
- Concepts and Theories
- Directly at UZH
- Quantum Simulations of Gauge Theories
- Does not take place this semester.
- Effective Field Theories for Particle Physics
- Special Students UZH must book the module PHY578 directly at UZH.
- Introduction to String Theory
- String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

Possible content:
- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- critical dimension and no-ghost theorem
- D-branes, T-duality
- two-dimensional conformal field theories

Prerequisites / notice
QFT-I (mandatory) and QFT-II (highly recommended)

402-0836-16L Quantum Simulations of Gauge Theories
402-0845-61L Effective Field Theories for Particle Physics
402-0897-00L Introduction to String Theory

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The "IT at D-PHYS" introduction provides a good understanding of how IT works at D-PHYS and presents an overview of the IT services and their providers. It is recommended for everyone joining the department.

The "IT and Information Security" crash course will address the most common threats you'll encounter when using the internet and teach you how to fend them off.

The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges.

The "Linux Basics" modules offer an introduction to the Linux landscape and show how to work on the shell by using command line tools. The first part provides a basic understanding of Linux systems and their components. It introduces commands essential to working with local and remote machines. The second part focuses on more advanced tools and workflows and provides guidelines to scripting, automation and customization.

The "Python Ecosystem" modules present various aspects of the environment around Python. Without teaching the Python programming language itself, it aims at providing understanding of various concepts surrounding it. The first part focuses on getting ready to run code. It discusses the management of Python interpreters, packages and virtual environments. The second part presents tools for writing Python code and interacting with strings. From development environments (IDE, Jupyter), over code formatters and linters, to string formatting and parsing with regular expressions. The third part sits at the interface between Python code and external data files. We explain how to read or write files, discuss data types and file formats. We show how to handle configuration parameters and mention tools to automate the data analysis.

The "System Aspects module" deals with the hardware-related side of scientific computing. To get the best performance out of your scientific code, you have to be aware of the underlying hardware and adapt to it.

Use the dedicated web page https://www.lehrbetrieb.ethz.ch/laboppraktika to register. Enrolled students are eligible for an attestation of attendance after visiting at least 3 out of the 5 modules. Refer to https://compenv.phys.ethz.ch for the detailed contents.

The course gives an introduction to symmetry groups in physics. It explains the relevant mathematical background (finite groups, Lie groups and algebras as well as their representations), and illustrates their important role across modern physics.

The aim of the course is to give a self-contained introduction into finite group theory as well as Lie theory from a physicists point of view. Abstract mathematical constructions will be illustrated with examples from physics.

Finite group theory, including representation theory and character methods; applications to crystallography and solid state physics. The symmetric group and the structure of its representations; applications to identical particles. Clifford algebras; application to relativistic wave equations equations. Simple Lie algebras and their finite-dimensional representations. Description of representations of SU(N) in terms of Young diagrams; applications in particle physics.
The objective of this course is to understand how the electronic properties of carbon-based materials can be exploited for fabricating...
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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<th>Duration</th>
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<th>Hours</th>
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<tr>
<td>402-0180-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students in Physics</td>
<td></td>
<td>1</td>
<td>2G</td>
<td>N. Beisert, V. Bondar, M. Christl</td>
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| Semester          | |
|-------------------||
| Autumn Semester 2024 |
Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a context specific to research in physics.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

Content
Part I: A self-paced e-learning course in Moodle consisting of several modules on the foundations of ethics in research:
- introduction to moral theory
- introduction to ethical issues that occur within scientific research (authorship, cooperation, data use and sharing as well as other aspects that are subject to scientific integrity and good scientific practice).
- collecting resources: presentation of a variety of tools and resources that help identify ethical issues
- setting up a strategy: example examination of a case regarding its ethical scope
- making decisions: presentation of different ways of addressing ethical issues by making hard choices, solving ethical dilemmas and seeking advice.

Part II: Two face-to-face workshops focus on applications and physics-specific aspects providing an interactive learning environment. Participants get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students. The workshops consist of several modules on:
- ethics introduction
- dilemma discussions
- case analyses
- group work and discussions
- role plays
- sustainability aspects
- dialogues with supervisor

Prerequisites / notice
For doctoral students of D-PHYS only.

Competencies
Method-specific Competencies
Analytical Competencies
Decision-making
fostered
Problem-solving
fostered

Social Competencies
Communication
fostered
Cooperation and Teamwork
fostered
Leadership and Responsibility
fostered
Sensitivity to Diversity
fostered
Negotiation
fostered

Personal Competencies
Adaptability and Flexibility
fostered
Critical Thinking
fostered
Integrity and Work Ethics
assessed
Self-awareness and Self-reflection
fostered
Self-direction and Self-management
fostered

851-0373-00L Learning to Teach
This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities.

Abstract
This course imparts a variety of teaching skills which will help Doctoral Teaching Assistants with their teaching tasks.

Objective
In this course Doctoral Teaching Assistants will...
• discuss learning science and teaching techniques with peers.
• design the introduction of their course/lecture/exercise class.
• develop learning activities according to learning objectives.
• practice classroom assessment techniques in order to measure student learning.
• engage in peer feedback in order to improve own teaching.

Content
We will meet for the mandatory kick-off meeting online in October. You will get detailed information together with the invitation email in the first week of the semester. The online phase, where you work through 6 modules in the Moodle course page will end in November. We will meet also face-to-face for the Consolidation workshop. You will find more information on the course page in Moodle.

The consolidation workshop will take place in November. Dates will be announced at the beginning of the semester.

Prerequisites / notice
This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities (exercises, excursions, supervision of practicals, lectures, etc.) or those who will assume teaching tasks in the semester following the programme. No previous teacher training is required.

Competencies
Subject-specific Competencies
Concepts and Theories
fostered

Method-specific Competencies
Media and Digital Technologies
fostered

Social Competencies
Communication
fostered
Cooperation and Teamwork
assessed

Personal Competencies
Adaptability and Flexibility
fostered
Critical Thinking
assessed
Self-awareness and Self-reflection
assessed
Self-direction and Self-management
fostered

Integration into Scientific Community

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<tr>
<th>Number</th>
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<td>1 credit</td>
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- Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 912 of 2667
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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**Doctorate Physics - Key for Type**

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<td>Eligible for credits</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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**Key for Hours**

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<td>G</td>
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<td>U</td>
<td>exercise</td>
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<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Doctorate Environmental Systems Sciences

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Subject Specialisation

Agricultural Sciences

Further courses: Subject Specialisation

Animal Sciences

Plant Sciences

Agriculture Economics

Graduate Programme in Plant Sciences

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<tr>
<th>Number</th>
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<td>Current Topics in Grassland Sciences (autumn)</td>
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<td>N. Buchmann</td>
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<tr>
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<td>Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as by doctoral and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.</td>
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<tr>
<td>Objective</td>
<td>Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.</td>
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<tr>
<td>Content</td>
<td>Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as by doctoral and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.</td>
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<td>Competencies</td>
<td>Subject-specific Competencies: Concepts and Theories assessed</td>
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<td>Method-specific Competencies: Analytical Competencies assessed</td>
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<td>Social Competencies: Communication assessed</td>
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<td></td>
<td>Personal Competencies: Critical Thinking assessed, Self-direction and Self-management assessed</td>
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<thead>
<tr>
<th>551-0205-00L</th>
<th>Challenges in Plant Sciences</th>
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<tbody>
<tr>
<td>Number of participants limited to 40.</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The colloquium “Challenges in Plant Sciences” is a core class of the Zurich-Basel Plant Science Center’s PhD program. The colloquium introduces participants to the broad spectrum of plant sciences within the network. The course offers the opportunity to approach interdisciplinary topics in the field of plant sciences.</td>
</tr>
<tr>
<td>Objective</td>
<td>Objectives of the colloquium are: Introduction to recent research in all fields of plant sciences. Developing presentation and discussion skills.</td>
</tr>
<tr>
<td>Content</td>
<td>The topics encompass integrated knowledge on current plant research, ranging from the molecular level to the ecosystem level, and from basic to applied science while making use of the synergies between the different research groups within the PSC.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies: Concepts and Theories assessed</td>
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<td></td>
<td>Method-specific Competencies: Analytical Competencies assessed</td>
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<tr>
<td></td>
<td>Social Competencies: Communication fostered, Cooperation and Teamwork fostered</td>
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<td></td>
<td>Personal Competencies: Self-direction and Self-management fostered</td>
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<thead>
<tr>
<th>551-0209-00L</th>
<th>Sustainable Plant Systems (Seminar)</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>Agriculture, food and waste management should use less resources to accept the planetary boundaries. The focus of the seminar is: (1) Agroecological systems. Can we transform the impact of agricultural in Switzerland and beyond? (2) Food system transformation. How can local sustainable food systems be built and scaled through policy strategies, food environments and consumer habits.</td>
</tr>
<tr>
<td>Objective</td>
<td>Participants will be able to: (1) Review issues of sustainability in the context of plant science research and literature on sustainable agriculture and the food system. (2) Analyze and interact on several case studies on agro-ecology and the food system.</td>
</tr>
<tr>
<td>Content</td>
<td>Future society has to feed nine billion people, therefore agriculture and food, waste and resource management have to go hand in hand toward the use of less resources and acceptance of the limits of Planetary Boundaries. The focus of the seminar will be: (1) Research in agroecological systems. Can we transform the impact of agricultural in Switzerland and beyond? (2) Food system transformation. How can local sustainable food systems be built and scaled through policy strategies, food environments and consumer habits.</td>
</tr>
<tr>
<td>Case studies (CS) will include:</td>
<td>CS 1: How can Swiss farmers move to zero environmental impact? CS 2: What influence do the consumers in developed (importing) countries have on sustainability of (mainly) small-holder farming in the developing (sourcing) countries? CS 3: Sensor based fertilization techniques at the filed for sustainability? CS 4: The blessing and curse of nitrogen – transferring knowledge from Science to Society to create more awareness. CS 5: The transformation of the (urban) food systems and changing consumer food habits.</td>
</tr>
</tbody>
</table>
Analytical Competencies fostered

Material will be handed out in the course.

Subject-specific Competencies

Communication fostered

Cooperation and Teamwork fostered

Self-presentation and Social Influence fostered

Personal Competencies

Creative Thinking fostered

Critical Thinking assessed

Self-awareness and Self-reflection fostered

Self-direction and Self-management fostered

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**751-1050-00L Compositional Data Analysis (CODA)**

**Participants of PhD Program in Plant Sciences have priority - open to other PhD students if places are available.**

*Please register additionally to the registration in ETHZ course catalogue here: https://ethz.ch/staffnet/en/service/courses-continuing-education.html (select Plant Sciences)*

**Abstract**

Compositional data analysis is a methodology used to describe the parts/compounds of a whole, conveying relative information. Typical examples in different fields are: geology (geochemical elements), medicine (body composition: fat, bone, lean), food industry (food composition: fat, sugar, etc), chemistry (chemical composition), ecology (abundance of different species), agriculture (nutrient balance)

**Objective**

Students will be able to:
- decide where (and where not) methods for analyzing compositional data can be used
- describe what their properties are and what challenges are associated with them, and to decide which method to choose for their research task
- critically evaluate the model results of a compositional data approach in the context of plant science.

**Content**

The objective of this course is to introduce students with a basic programming background to compositional data analysis. We will discuss topics like the geometric properties of compositional data in plant science including the representation of data in so-called log-ratio coordinates, exploratory data analysis and visualization, location and correlation measures, application to multivariate analysis (e.g. cluster analysis), linear models and we give an outline on problems for high-dimensional data. In addition, problems with missing values, zeros and outliers are discussed. The course will consist of 50% lectures and 30% hands-on programming in R, where students will directly apply methods in software to help solving problems in plant sciences, and 20% is spent on a given task.

**Literature**


**Prerequisites / notice**

Participants should bring their laptops to the exercises with the R software environment and a suitable editor (e.g. RStudio) installed. It is assumed that students enrolling in this course have successfully completed a fundamentals of data science or statistics course and are familiar with programming (preferably in R).


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**701-1425-01L Genetic Diversity: Techniques**

This course provides laboratory training for advanced students (master, doctoral or post-doctoral level). Various DNA/RNA extraction protocols, quality control measurements, SNP genotyping and gene expression techniques will be addressed. This is a course for practitioners.

**Abstract**

To learn and improve on standard and modern methods of genetic data collection. With a focus on: Use of different DNA/RNA extractions protocols, techniques for DNA/RNA quality control measurements, gene expression and SNP genotyping techniques.

**Objective**

- study the processes and steps involved in genetic data collection and analysis
- understand the advantages and disadvantages of the different techniques.

**Content**

Techniques addressed are: RNA/DNA extractions and quality control, SNP genotyping and real-time qPCR.

**Lecture notes**

Material will be handed out in the course.

**Literature**

Material will be handed out in the course.

**Prerequisites / notice**

There will be two afternoons in class. The lab work in between the afternoons is done by the students according to their own schedule but with the support of the teacher and must be completed after 3 weeks. The workload is approximately 1-2 full days per week, depending on the student's ability. Student must know how to pipette.

**Competencies**

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<tr>
<th>Subject-specific Competencies</th>
<th>Conceptual and Theoretical Concepts and Theories</th>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>fostered</td>
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**751-1060-00L Introduction to Light Microscopy and Image Processing**

*Does not take place this semester.*

**For PhD students. Students of University of Zurich and of Basel have full access, but registration is only valid if registered at: https://www.ethz.ch/services/en/service/courses-continuing-education.html* Choose Plant Sciences “Sustainable Plant Systems”

**Abstract**

This 3-day course gives a basic introduction into light microscopy. The course offers a combination of theoretical introduction with hands-on sessions teaching the fundamentals of light microscopy including transmission with phase contrast and DIC, wide-field fluorescence, deconvolution and 3D microscopy methods such as confocal imaging, including laser scanning point confocal microscopy and spin microscopy.

**Objective**

The students learn the concept of resolution, the different ways to create contrast and how to set up a light microscope for transmission and fluorescence imaging. Students also learn how to setup the microscope for confocal imaging, laser scanning and spinning disk, and how to operate the different acquisition modes to acquire multichannel and 3D/4D (time-lapse) image stacks.
### Aerosols I: Physical and Chemical Principles

**Number** 701-1239-00L  
**Title** Aerosols I: Physical and Chemical Principles  
**Type** W  
**ECTS** 4 credits  
**Hours** 2V+1U  
**Lecturers** M. Gysel Beer, D. Bell, E. Weingartner

**Abstract**
Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

**Objective**
- Physical and chemical principles:
  - know the processes and physical laws of aerosol dynamics.
  - understand the thermodynamics of phase equilibria and chemical equilibria.
  - know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

- Experimental methods:
  - know the most important chemical and physical measurement instruments.
  - understand the underlying chemistry and physics.

- Environmental impacts:
  - know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
  - know the most important climate impacts of atmospheric aerosols.

Lecture notes: material is distributed during the lecture.

**Literature**

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories assessed
- Techniques and Technologies assessed

**Method-specific Competencies**
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

**Social Competencies**
- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

**Personal Competencies**
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

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### Cloud Microphysics

**Number** 701-1235-00L  
**Title** Cloud Microphysics  
**Type** W  
**ECTS** 4 credits  
**Hours** 2V+1U  
**Lecturers** Z. A. Kanji, J. Chen, C. Zhang

**Abstract**
Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes.

**Objective**
- The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles to interpret atmospheric observations of clouds and precipitation.

**Content**
see: http://www.iac.ethz.ch/edu/courses/master/modules/cloud-microphysics.html  
and: https://moodle-app2.let.ethz.ch/course/view.php?id=15424
The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

The students are expected to read chapters of this textbook prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth. Check the course website for lecture dates and location.


In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Attendance is mandatory.

The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions.

The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.
The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces

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<th>Competencies</th>
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<tbody>
<tr>
<td>701-1253-00L</td>
<td>Analysis of Climate and Weather Data</td>
<td>W 3 credits</td>
<td>2G</td>
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</tbody>
</table>

Abstract
An introduction to methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of predictions, principal component analysis.

Course goals: Participants understand the theoretical concepts and purpose of methods, can apply them independently, and know how to interpret results professionally.

Objective
Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.

Content
The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis, detection and attribution.

The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.

Lecture notes
Documentation and supporting material:
- slides used during the lecture
- exercise sets and solutions
- R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

Literature
For complementary reading:
- Prerequisites / notice

Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Problem-solving
- Communication
- Cooperation and Teamwork

Method-specific Competencies

Social Competencies

Personal Competencies

Fostered

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1315-00L</td>
<td>Isotopes and Biomarkers in Biogeochemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>C. Schubert, N. Casacuberta Arola, R. Kipfer</td>
</tr>
</tbody>
</table>

Abstract
The course introduces the scientific concepts and typical applications of tracers in biogeochemistry. The course covers stable and radioactive isotopes, geochemical tracers and biomarkers and their application in biogeochemical processes as well as regional and global cycles. The course provides essential theoretical background for the lab course “Isotopic and Organic Tracers Laboratory”.

Objective
The course aims at understanding the fractionation of stable isotopes in biogeochemical processes. Students learn to know the origin and decay modes of relevant radiogenic isotopes. They discover the spectrum of possible geochemical tracers and biomarkers, their potential and limitations and get familiar with important applications.

Content
Geogenic and cosmogenic radionuclides (sources, decay chains); stable isotopes in biogeochemistry (natural abundance, fractionation); geochemical tracers for processes such as erosion, productivity, redox fronts; biomarkers for specific microbial processes.

Lecture notes
Handouts will be provided for every chapter.

Literature
A list of relevant books and papers will be provided.

Prerequisites / notice
Students should have a basic knowledge of biogeochemical processes (BSc course on Biogeochemical processes in aquatic systems or equivalent).

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<tr>
<td>701-1315-00L</td>
<td>Biogeochemistry of Trace Elements</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Voegelin, D. Janssen, L. Winkel</td>
</tr>
</tbody>
</table>

Abstract
The course addresses the biogeochemical classification and behavior of trace elements, including key processes driving the cycling of important trace elements in aquatic and terrestrial environments and the coupling of abiotic and biotic transformation processes of trace elements. Examples of the role of trace elements in natural or engineered systems will be presented and discussed in the course.

Objective
The students are familiar with the characteristic features of the environment and fate, and the biogeochemical reactivity of different groups of trace elements. They are able to apply their knowledge on the interaction of trace elements with geosphere components and on abiotic and biotic transformation processes of trace elements to discuss and evaluate the behavior and impact of trace elements in aquatic and terrestrial systems.

Content
(i) Definition, importance and biogeochemical classification of trace elements. (ii) Key biogeochemical processes controlling the cycling of different trace elements (base metals, redox-sensitive and chalcophile elements, volatile trace elements) in natural and engineered environments. (iii) Abiotic and biotic processes that determine the environmental fate and impact of selected trace elements.

Lecture notes
Selected handouts (lecture notes, literature, exercises) will be distributed during the course.

Prerequisites / notice
Students are expected to be familiar with the basic concepts of aquatic and soil chemistry covered in the respective classes at the bachelor level (soil mineralogy, soil organic matter, acid-base and redox reactions, complexation and sorption reactions, precipitation/dissolution reactions, thermodynamics, kinetics, carbonate buffer system).

The lecture 701-1315-00L Biogeochemistry of Trace Elements is a prerequisite for attending the laboratory course 701-1331-00L Trace Elements Laboratory, or students must be concurrently enrolled in 701-1315-00L Biogeochemistry of Trace Elements in the same semester.
Future climate change can only be kept within reasonable bounds when CO₂ emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

None

None

Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

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<th>Competencies</th>
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<th>Conceptual and Theoretical Knowledge</th>
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<td></td>
<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Personal Competencies</td>
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<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
</tbody>
</table>

Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

Publications and class notes can be downloaded from a web page announced during the lecture.

Papers will be assigned and downloaded from a web page announced during the lecture.

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<td>Leadership and Responsibility</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Critical Thinking</td>
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<td>Self-awareness and Self-reflection</td>
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The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

Powerpoint slides are available on the moodle page. Additional documents are handed out as copies.

Basic literature and references are listed on the webpage.

The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie
This five-day winter school aims at teaching advanced Master students, PhD students and postdoctoral researchers on aspects of the genomics of environmental adaptation. It provides both theoretical background and hands-on exercises on major topics of contemporary environmental genomics such as signatures of selection, outlier analysis, genotype-environment associations, or GWAS. This five-day winter school introduces students to some major concepts and methods of environmental genomics, i.e., (i) how the environment and adaptive genetic variation are related and (ii) how signatures of genomic adaptation can be detected in natural populations. The winter school focuses on current methods and hands-on exercises, emphasizing an understanding of the underlying concepts and a discussion of benefits, limitations and pitfalls of environmental genomics. It is specifically aimed at the needs of advanced Master students, PhD students and early postdoctoral researchers.

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Problem-solving: assessed
  - Project Management: fostered
  - Techniques addressed are: RNA/DNA extractions and quality control, SNP genotyping and real-time qPCR.
- Social Competencies
  - Communication: fostered
  - Cooperation and Teamwork: assessed
  - Negotiation: fostered
- Personal Competencies
  - Adaptable and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Self-direction and Self-management: fostered

**Genomics of Environmental Adaptation**

**Abstract**
This five-day winter school aims at teaching advanced Master students, PhD students and postdoctoral researchers on aspects of the genomics of environmental adaptation. It provides both theoretical background and hands-on exercises on major topics of contemporary environmental genomics such as signatures of selection, outlier analysis, genotype-environment associations, or GWAS. This five-day winter school introduces students to some major concepts and methods of environmental genomics, i.e., (i) how the environment and adaptive genetic variation are related and (ii) how signatures of genomic adaptation can be detected in natural populations. The winter school focuses on current methods and hands-on exercises, emphasizing an understanding of the underlying concepts and a discussion of benefits, limitations and pitfalls of environmental genomics. It is specifically aimed at the needs of advanced Master students, PhD students and early postdoctoral researchers.

**Objective**
The genomics of environmental adaptation is an evolving scientific field of both basic and applied interest. Researchers make increasing use of diverse methodological approaches built on concepts from ecology, evolutionary biology and population genomics. This five-day winter school introduces students to some major concepts and methods of environmental genomics, i.e., (i) how the environment and adaptive genetic variation are related and (ii) how signatures of genomic adaptation can be detected in natural populations. The winter school focuses on current methods and hands-on exercises, emphasizing an understanding of the underlying concepts and a discussion of benefits, limitations and pitfalls of environmental genomics. It is specifically aimed at the needs of advanced Master students, PhD students and early postdoctoral researchers.

**Content**
Topics:
(1) Molecular markers and next generation sequencing techniques; neutral and adaptive genetic variation, genetic drift and genetic population structure.
(2) Outlier analysis: concept, methodology and types of outlier analyses.
(3) Environmental data: which environmental data are available and used to identify signatures of adaptation; data limitations; collinearity.
(4) Genotype-environment associations (landscape genomics): concept and types of genotype-environment associations; false discovery rates; genomic offset.
(5) Genotypes and phenotypes: GWAS; follow-up analyses.

**Lecture notes**
Hand-outs will be distributed.

**Prerequisites / notice**
Grading will be according to a written report (8-10 pages), in which students will have to design a complete study in environmental genomics, and according to student contributions during the course.

Prerequisites: students must have good knowledge in population genetics and evolutionary biology and some experience with R.
Zürich Ecology and Evolution Interaction Seminar

A. Hall

Interaction seminar. Student-led presentations, guest and discussions on current themes in ecology, evolution and population biology.

Students gain competences in presenting their work orally, leading discussions about current topics in ecology and evolution, interacting with colleagues from various subdisciplines, and engaging in critical dialogue about ongoing research projects.

Scientific presentations by doctoral students about ongoing research projects; guest presentations by established researchers, interactive discussions about current research in ecology, evolution and population biology.

Communication

Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of 'environmental governance' and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Furthermore, we encourage the development of soft skills by engaging students in activities such as moderating discussions in class, presenting own proposals, giving regular peer feedback, as well as critically reflecting on various relevant publications in the environmental governance domain.

During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

For information, location and details: https://pe.ethz.ch/education/zis.html

Environmental Systems Policy

Environmental Governance

The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

To analyze the evolution as well as the key elements of environmental governance.

To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of 'environmental governance' and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Furthermore, we encourage the development of soft skills by engaging students in activities such as moderating discussions in class, presenting own proposals, giving regular peer feedback, as well as critically reflecting on various relevant publications in the environmental governance domain.

Lecture slides, a script and additional course material will be provided on Moodle.

A detailed course schedule will be made available at the beginning of the semester.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)
Subject-specific Competencies
- Concepts and Theories: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

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**Forest and Landscape Management**

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<tr>
<td>701-1631-00L</td>
<td>Foundations of Ecosystem Management</td>
<td>W</td>
<td>5</td>
<td>3G</td>
<td>J. Ghazoul, A. Giger Dray</td>
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**Abstract**

This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

**Objective**

Students should be able to:

a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.
b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

d) understand the complexity of ecosystem management and its implications for decision making.

e) knowledge of the scientific principles and methodologies that underpin ecosystem management.

**Content**

Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

**Lecture notes**

No Script

**Literature**


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**Environmental Governance**

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<td>701-1651-00L</td>
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<td>W</td>
<td>6</td>
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<td>E. Lieberherr</td>
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**Abstract**

The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.
This course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to ecological research questions. Topics will focus on carbon fluxes and to integrate processes spatially and temporally.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of ‘environmental governance’ and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Furthermore, we encourage the development of soft skills by engaging students in activities such as moderating discussions in class, presenting own proposals, giving regular peer feedback, as well as critically reflecting on various relevant publications in the environmental governance domain.

During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy).

This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions.

The lectures and the course material will be provided on Moodle. Lecture slides, a script and additional course material will be provided on Moodle. A detailed course schedule will be made available at the beginning of the semester.

To analyze the evolution as well as the key elements of environmental governance.

To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and how we use and manage natural resources. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.
Abstract
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

Objective
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:
1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

Content
Die Lehrveranstaltung gibt einen Einblick in die heutige Erdbefoachtung mit dem folgenden skizzierten Inhalt:
1. Einführung in die Fernerkundung von Luft- und Weltraum gestützten Systemen
2. Einführung in das Elektromagnetische Spektrum
3. Einführung in optische Systeme (optisch und hyperspektoral)
4. Einführung in Mikrowellen-Technik (aktiv und passiv)
5. Einführung in atmosphärische Systeme (meteo und chemisch)
6. Einführung in die Techniken und Methoden zur Bestimmung von Umweltparametern
7. Einführung in die Anwendungen zur Bestimmung von Umweltparametern in der Hydrologie, Glaziologie, Forst und Landwirtschaft, Geologie und Topographie

Lecture notes
Folien zu jedem Vorlesungsblock werden zur Verfügung gestellt.

Literature
Ausgewählte Literatur wird am Anfang der Vorlesung vorgestellt.

701-1776-00L Geographic Data Processing with Python and ArcGIS
W 1 credit 2U A. Baltensweiler

Abstract
The course communicates the basics of the Python programming language and provides a general introduction to the ArcGIS Pro Python scripting framework. It also introduces several Python libraries (pandas, numpy, scpy, statmodels, geopandas, rasterio) that greatly extend the capabilities of spatial data analysis and modelling.

Objective
Students will learn the basics of geographic data processing using the Python programming language and ArcGIS Pro (arcpy). They will be able to implement their own geoprocessing scripts for spatial data analysis and modelling. Students will be able to integrate open source libraries into their Python scripts and know how to apply the libraries to geospatial datasets.

Content
The course covers basic Python language concepts such as data types, control structures and functions. These concepts are then used to gain a deeper understanding of ArcGIS Pro's geoprocessing framework (arcpy). This includes vector data processing functions as well as geoprocessing functions for raster data analysis. It also introduces the use of key Python libraries in conjunction with geospatial datasets.

Lecture notes
Lecture notes, exercises and worked-out solutions will be provided.

Literature

Prerequisites / notice
Basic knowledge of ArcGIS is assumed.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered
Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

701-1682-00L Dendroecology
W 3 credits 3G C. Bigler, K. Treydte, G. von Arx

Abstract
The course dendroecology offers theoretical and practical aspects of dendrochronology. The impact of different environmental influences on tree-ring characteristics will be shown. The students learn various methods to date tree rings and they understand how ecological and environmental processes and patterns can be reconstructed using tree rings.

Objective
The students...
- understand, how wood is configured and how tree-ring structures are formed.
- are able to identify and describe different tree-ring structures.
- understand the theoretical and practical aspects of the dating of tree rings.
- know the effects of different abiotic and biotic environmental influences (climate, site, competition, insects, fire, physical-mechanical influences) on trees and tree rings.
- discover a tool for understanding and reconstructing global change processes.
- learn software to date, standardize and analyze tree rings.
- get hands-on experience based on the demonstration of wood (increment cores, stem discs, wedges), sampling in the field, and measuring and dating of tree rings in the tree-ring lab.
- solve R-based exercises (R tutorial will be provided) and answer questions in Moodle.
- work out an independent research question related to a dendroecological topic and write a short literature review based on scientific papers.

Content
- Overview and history of dendrochronology
- Principles of dendrochronology
- Formation and structure of wood and tree rings
- Wood anatomy and intra-seasonal tree-ring growth
- Continuous and discontinuous tree-ring characteristics
- Sampling and measuring of tree rings
- Crossdating methods (visual, skeleton plots, quantitative)
- Defrending and standardization of tree-ring series
- Development of tree-ring chronologies
- Water transport in trees
- Stable isotopes in tree rings
- Climate influences, climate-growth relationships, climate reconstructions
- Reconstruction of forest dynamics (regeneration, growth, competition, mortality)
- Disturbance ecology (fire, insects, blowdown)
- Application of tree-ring research in practice and in interdisciplinary research projects
- Field and lab day (date will be searched together with the students in the beginning of the semester): discussion of different dendroecological questions in the forest; sampling of trees; insight into different tree-ring projects in the lab (Swiss Federal Institute for Forest, Snow and Landscape Research WSL)
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and fosters emerging Analytical Competencies.

Abstract
Invited external speakers present their research on current issues in the field of soil science and discuss their results with the participants.

Objective
Master and PhD students are introduced to current areas of research in soil sciences and get first-hand experience in scientific discussion.

Content
The seminar covers the following topics:
(1) Theories and concepts of inter- and transdisciplinary research
(2) The specific challenges of inter- and transdisciplinary research
(3) Collaborating between different disciplines
(4) Engaging with stakeholders
(5) 10 steps to make participants’ research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges. They learn to critically reflect their own research project in its societal context and on their role as scientists.

Literature
The following open access article builds a core element of the course:
available at (open access): http://www.ingentaconnect.com/contentone/oekom/gaia/2017/00000026/0000001/art00011
Further, this collection of tools will be used:
https://naturalsciences.ch/topics/co-producing_knowledge
https://www.shapeidtoolkit.eu

Prerequisites / notice
Participation in the course requires participants to be working on their own research project.

Lecture notes
Lecture notes (in English) will be handed out in the class.

The lecture notes and further documents (papers, software) can be downloaded from Moodle (https://moodle-app2.let.ethz.ch) following registration for the course.

Competencies
Subject-specific Competencies
- Concepts and Theories: fostered
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: fostered

Personal Competencies
- Critical Thinking: fostered

Technologies (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: 10SMVBD

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline_s.html

Abstract
Technological innovation and emerging technologies may enable or disrupt environmental, economic or societal improvements. A responsible way forward considers values in the development of the technologies. The blended-learning course with face-to-face block course elements, self-learning phases and case studies is at the intersection between technology ethics and value-sensitive design.
This course introduces students to foundational texts that led to the emergence of the environment as a subject of scientific importance, and shaped its relevance to society. Above all, the course seeks to give confidence and raise enthusiasm among students to read more widely around the broad subject of environmental sciences and management both during the course and beyond.

The course will provide students with opportunities to read, discuss, evaluate and interpret key texts that have shaped the environmental movement and, more specifically, the environmental sciences. Students will gain familiarity with the foundational texts, but also understand the historical context within which their academic and future professional work is based. More directly, the course will encourage debate and discussion of each text that is studied, from both the original context as well as the modern context. In so doing students will be forced to consider and justify the current societal relevance of their work.

The specific texts selected for discussion will vary, but examples include:

- Leopold (1949) A Sand County Almanach
- Carson (1962) Silent Spring
- Jared Diamond (2005) Collapse

The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is not a scientific paper) to identify the key points for discussion.

Thereafter, in each week a text (typically a chapter from a book or a paper) considered to be seminal or foundational will be assigned by a course lecturer. The lecturer will introduce the selected text with a brief background of the historical and cultural context in which it was written, with some additional biographical information about the author. He/she will also briefly explain the justification for selecting the particular text.

The students will read the text, with two to four students (depending on class size) being assigned to present it at the next session. Presentation of the text requires the students to prepare by, for example:

- identifying the key points made within the text
- identifying issues of particular personal interest and resonance
- considering the impact of the text at the time of publication, and its importance now
- evaluating the text from the perspective of our current societal and environmental position

Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

The course will be assessed through a final project, as well as a series of short papers and presentations throughout the course. The specific assessment criteria will be outlined in the course syllabus.

### Literature

The specific texts selected for discussion will vary, but examples include:

- Leopold (1949) A Sand County Almanach
- Carson (1962) Silent Spring
- Jared Diamond (2005) Collapse

### Competencies

- **Subject-specific Competencies**
  - Concepts and Theories: fostered
  - Media and Digital Technologies: fostered
  - Communication: assessed
  - Cooperation and Teamwork: fostered
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: assessed
  - Negotiation: assessed

- **Method-specific Competencies**
  - Adaptability and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: fostered

### Prerequisites / notice

Good English Skills are necessary.
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
The students are able to
● frame a data science problem and build a hypothesis
● describe the steps of a typical data science project workflow
● conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
● critically think about the limits and implications of a method
● visualise data and results throughout the workflow
● access online resources to keep up with the latest data science methodology and deepen their understanding

Content
● The data science workflow
● Access and handle (large) datasets
● Prepare and clean data
● Analysis: data exploratory steps
● Analysis: machine learning and computational methods
● Evaluate results and analyse uncertainty
● Visualisation and communication

Prerequisites / notice
252-0640-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

Transferable Skills

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<th>Number</th>
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<td>701-5001-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students W</td>
<td>1 credit</td>
<td>1S</td>
<td>N. Gruber, E. Lieberherr, A. Widmer</td>
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Abstract
This course sensitises doctoral students to ethical issues that may arise during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students are given the opportunity to apply their knowledge and train their newly acquired skills in an interactive, discipline specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. Furthermore, they are encouraged to reflect on their professional role as scientific researchers.

Content
Part I
The self-paced e-learning course consists of 5 modules:

Module 1: Ethics
Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices or solve ethical dilemmas).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects in the general area of Environmental Sciences. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only

Competencies
Subject-specific Competencies
Method-specific Competencies
Personal Competencies
Concepts and Theories
Decision-making
Critical Thinking
assessed
assessed
assessed

900-0100-DRL | Transferable Skills Course I (1-3 days) W | 1 credit | 2S | Lecturers

Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

900-0101-DRL | Transferable Skills Course II (1-3 days) W | 1 credit | 2S | Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
### Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

### Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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**Data:** 02.07.2024 12:39  
**Autumn Semester 2024**  
**Page 929 of 2667**
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

### Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.

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**Integration into Scientific Community**
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Participation in summer or winter schools with a maximum duration of 3 days.

**Objective**
Participation in summer or winter schools with a maximum duration of 3 days.

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Autumn Semester 2024
### Summer School III (1 week, with Poster or Talk)

- **Code:** 900-0161-DRL
- **Credit:** 3 credits
- **ECTS:** 6K
- **Objective:** Participation in summer or winter schools with a minimum duration of 1 week. Participants need to present either a poster or a talk at this occasion.
- **Lecturers:**

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### External Conference I (incl. Poster or Talk)

- **Code:** 900-0162-DRL
- **Credit:** 1 credit
- **ECTS:** 2K
- **Objective:** Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **Lecturers:**

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### External Conference II (incl. Poster or Talk)

- **Code:** 900-0163-DRL
- **Credit:** 1 credit
- **ECTS:** 2K
- **Objective:** Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **Lecturers:**

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### External Conference III (incl. Poster or Talk)

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### Doctorate Environmental Systems Sciences - Key for Type

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### Key for Hours

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<td>exercise</td>
<td>D</td>
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<td>seminar</td>
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<td>revision course / private study</td>
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<td>K</td>
<td>colloquium</td>
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ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Electrical Engineering and Information Technology Bachelor

### 1st Semester

#### First Year Examinations

##### First Year Examination Block A

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<tr>
<th>Number</th>
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<tr>
<td>227-0003-00L</td>
<td>Digital Circuits</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>M. Luisier</td>
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</table>

**Abstract**
Digital and analogue signals and their representation, logic gates, transistors, combinational and sequential circuits and systems, boolean algebra, Karnaugh-maps, finite state machines, memory and computing building blocks in CMOS technology.

**Objective**
Provide basic knowledge and methods to understand and to design digital circuits and systems.

**Content**
Digital and analogue signals and their representation. Boolean Algebra, circuit analysis and synthesis, the MOS transistor, CMOS logic, static and dynamic behaviour, Karnaugh-Maps, hazards, binary number systems, coding. Combinational and sequential circuits and systems (boolean algebra, K-maps, etc.). Memory building blocks and memory structures, programmable logic circuits. Finite state machines, architecture of microprocessors.

**Lecture notes**
Lecture notes for all lessons, assignments and solutions.

**Literature**
https://iis-students.ee.ethz.ch/lectures/digital-circuits/


**Prerequisites / notice**
No special prerequisites.

**Competencies**

<table>
<thead>
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<th>Concepts and Theories</th>
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| 401-0151-00L | Linear Algebra   | O    | 5 credits | 3V+2U | V. C. Gradinaru |

**Abstract**
Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decomposition, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.

**Objective**
Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte.

**Lecture notes**
eigenes Aufschrieb und K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002

**Literature**
K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002

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| 227-0001-00L | Networks and Circuits I | O    | 4 credits | 2V+2U | C. Franck |

**Abstract**
This course introduces the students into the basics of electric circuits, the underlying physical phenomena and required mathematical methods.

**Objective**
Voltage, current and properties of basic elements of electric circuits, i.e. capacitors, resistors and inductors should be understood in relation to electric and magnetic fields. Furthermore, the students should be able to mathematically describe, analyze and finally design technical realizations of circuit elements. Students should also be familiar with the calculation of voltage and current distributions of DC circuits. The effect and the mathematical formulation of magnetic induction should be known for technical applications.

**Content**
Electrostatic field; Stationary electric current flow; Basic electric circuits; current conduction mechanisms; time variant electromagnetic field.

**Lecture notes**

**Literature**
Manfred Albach, Elektrotechnik 978-3-86894-398-6 (2020)
Engineering Mechanics

Abstract: Introduction to engineering mechanics: kinematics, statics and dynamics of rigid bodies and systems of rigid bodies.

Objective: Students can solve problems of elementary engineering mechanics.

Content:
- Basic notions: position and velocity of particles, rigid bodies, planar motion, kinematics of rigid body, force, couple, power.
- Statics: static equivalence, force-couple system, center of forces, centroid, principle of virtual power, equilibrium, constraints, statics, friction.
- Dynamics: acceleration, inertial forces, d'Alembert's Principle, Newton's Second Law, principles of linear and angular momentum, equations of planar motion of rigid bodies.

Lecture notes: yes, in German

Literature:

First Year Examination Block B

Number Title Type ECTS Hours Lecturers
401-0231-10L Analysis 1 O 8 credits 4V+3U F. Ziltener

Abstract: Reelle und komplexe Zahlen, Grenzwerte, Folgen, Reihen, Potenzreihen, stetige Abbildungen, Differential- und Integralrechnung einer Variablen, Einführung in gewöhnliche Differentialgleichungen

Objective: Einführung in die Grundlagen der Analysis

Lecture notes: Christian Blatter: Ingenieur-Analysis (Kapitel 1-4)

Literature:
- Konrad Koenigsberger, Analysis I.
- Christian Blatter, Analysis I.

First Year Compulsory Laboratory Courses

Number Title Type ECTS Hours Lecturers
227-0005-10L Digital Circuits Laboratory O 1 credit 1P A. Emboras, M. Luisier

Abstract: Digital and analogue signals and their representation. Combinational and sequential circuits and systems, boolean algebra, Karnaugh-maps. Finite state machines. Memory and computing building blocks in CMOS technology, programmable logic circuits.

Objective: Deepen and extend the knowledge from lecture and exercises, usage of design software Quartus II as well as an oscilloscope

Content: The contents of the digital circuits laboratory will deepen and extend the knowledge of the correspondent lecture and exercises. With the help of the logic device design software Quartus II different circuits will be designed and then tested on an evaluation board. You will build up the control for a 7-digit display as well as an adder and you will create different types of latches and flip-flops. At the end of the laboratory a small synthesizer will be programmed that is able to play self-created melodies. At the same time the usage of a modern oscilloscope will be taught in order to analyse the programmed circuits through the digital and analogue inputs.

Lecture notes: Lecture notes for all experiments.

Prerequisites / notice: https://lis-students.ee.ethz.ch/lectures/digital-circuits/praktikum/
Preparatory Course in Computer Science

Abstract
The course provides an elementary introduction to programming with C++. Prior programming experience is not required.

Objective
Establish an understanding of basic concepts of imperative programming and how to systematically approach programming problems. Students are able to read and write simple C++ programs.

Content
This course introduces you to the basics of programming with C++. Programming means instructing a computer to execute a series of commands that ultimately solve a particular problem.

The course comprises the following:
- General introduction to computer science: development, goals, fundamental concepts
- Interactive self-study tutorial that provides an introduction to C++ and covers the following topics: variables, data types, conditional statements and loops
- Introduction to stepwise refinement as an approach to systematically solving programming problems
- Two small programming projects, to practically apply the studied fundamentals

Lecture notes
All teaching material is available online; an online development environment is used for the programming projects.

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252-0865-00L

Analysis 3

Abstract
In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.

Objective
The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

Content
1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)

2.) Quasilinear first order PDEs
- Solution with the method of characteristics
- Conservation laws
3.) Hyperbolic PDEs
- wave equation
- d'Alembert formula in (1+1)-dimensions
- method of separation of variables
4.) Parabolic PDEs
- heat equation
- maximum principle
- method of separation of variables
5.) Elliptic PDEs
- Laplace equation
- maximum principle
- method of separation of variables
- variational method

Literature

Prerequisites / notice
Prerequisites: Analysis I and II, Fourier series (Complex Analysis)
### Competencies

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<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
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</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>fostered</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### Conceptual Competencies

- **Signal theory and systems theory (continuous-time and discrete-time): Signal analysis in the time and frequency domains, signal spaces, Hilbert spaces, generalized functions, linear time-invariant systems, sampling theorems, discrete-time signals and systems, digital filter structures, Discrete Fourier Transform (DFT), finite-dimensional signals and systems, fast Fourier transform (FFT).**
- **Hilbert spaces, generalized functions, linear time-invariant systems, sampling theorems, discrete-time signals and systems, digital filter structures, Discrete Fourier Transform (DFT), finite-dimensional signals and systems, fast Fourier transform (FFT).**

### Objective

**Physics II**

The courses covers the foundations of design and analysis of algorithms and data structures, including graph theory and graph problems. It also introduces generic and parallel programming. Hands-on experience with implementing the aforementioned in C++.

### Content

- Asymptotic runtime (algorithmic complexity)
- Fundamental algorithmic problems, e.g. searching, sorting, shortest paths, spanning trees
- Classical data structures, e.g. search trees, balanced trees, heaps, hash tables
- Graph theory and graph problems
- Problem solving strategies as design patterns for algorithms, e.g. induction, divide and conquer, backtracking, dynamic programming
- Generic programming: C++ templates higher-order functions, lambdas, closures
- Parallel programming: (in)dependence of computations, parallelism and concurrency, shared memory, races, mutual exclusion, communication and synchronisation

### Literature


### Prerequisites

- **Methods:**
  - Physics I.

### Prerequisites / notice

- Prerequisites: Physics I.

### Learning outcomes

- **Student will:**
  - understand the basic postulates of quantum mechanics
  - understand the fundamental principles of quantum mechanics
  - apply mathematical methods for solving various problems including atoms, molecules, and solids.

### Subject-specific Competencies

- **Physics II**

<table>
<thead>
<tr>
<th>Competencies</th>
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</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
</tr>
<tr>
<td>Concepts and Theories</td>
</tr>
<tr>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
</tr>
<tr>
<td>Fostered</td>
</tr>
</tbody>
</table>

### 402-0053-00L Physics II

**Abstract**

The goal of the Physics II class is an introduction to quantum mechanics.

**Objective**

To work effectively in many areas of modern engineering, such as renewable energy and nanotechnology, students must possess a basic understanding of quantum mechanics. The aim of this course is to provide this knowledge while making connections to applications of relevance to engineers. After completing this course, students will understand the basic postulates of quantum mechanics and be able to apply mathematical methods for solving various problems including atoms, molecules, and solids. Additional examples from engineering disciplines will also be integrated.

**Content**

- Wave mechanics: the old quantum theory
- Postulates and formalism of Quantum Mechanics
- First application: the quantum well and the harmonic oscillator
- QM in three dimension: the hydrogen atom
- Identical particles: Pauli's principle
- Crystalline Systems and band structures
- Quantum statistics
- Approximation Methods
- Applications in Engineering
- Entanglement and superposition

**Lecture notes**

Lecture notes (hand-written) will be distributed via the Moodle interface.

**Literature**

Modern, transistor-based electronics has transformed our lives and plays a crucial role in our economy since the 2nd half of last century. Get to know and understand basic transistor and op amp based electronic circuits. Build and operate simple electronic circuits including oscillator and function generator based on an op amp. Characterization of a real operational amplifier with non-idealities; band pass filter with op amp, resistors and capacitors; data converters; domain measurements, impedance and transfer function measurements. In the lab we will have a closer look at the following topics and realizations. Switched-capacitor filters. Stabilization. Transimpedance amplifiers. Active filters: simple and biquadratic active RC-filters, higher order filters, biquad and ladder realizations. Switched-capacitor filters.

### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0077-10L</td>
<td>Electronic Circuits</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>H. Wang</td>
</tr>
<tr>
<td></td>
<td>Introductory lecture on electronic circuits. Transistor fundamentals, analysis and design of transistor based electronic circuits such as amplifiers and filters; operational amplifiers and circuits based thereon.</td>
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<tr>
<td></td>
<td>Modern, transistor-based electronics has transformed our lives and plays a crucial role in our economy since the 2nd half of last century. The main objective of this course in electronic circuits is to introduce the concept of the active device, including operational amplifiers, and their use in amplification, signal conditioning, switching and filtering to students. In addition to gaining experience with typical electronic circuits that are found in common applications, including their own Gruppenarbeit and Fachpraktikum projects, students sharpen their understanding of linear circuits based on nonlinear devices, imperfections of electronic circuits and the concept of design (as opposed to analysis). The course is a prerequisite for higher semester subjects such as analog integrated circuits, RF circuits for wireless communications, A/D and D/A converters and optoelectronics.</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0033-01L</td>
<td>Discrete Mathematics</td>
<td>O</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>U. Koch</td>
</tr>
<tr>
<td></td>
<td>Introduction to the foundations of discrete mathematics: set theory, combinatorics, graph theory and algebra. The foundations are demonstrated with applications from information technology.</td>
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<td></td>
<td>- You can apply set theory and its axioms as the foundation of mathematics.</td>
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<td></td>
<td>- You can solve counting problems using elementary counting methods and principles from combinatorics.</td>
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<td>- You can explain fundamental graph types and their properties.</td>
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<td></td>
<td>- You can determine the solution of classical graph problems (e.g. flows in networks).</td>
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<td></td>
<td>- You can use elementary number theory for applications in information theory.</td>
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<td></td>
<td>- You can demonstrate the basic algebraic structures and use them to implement error correction methods.</td>
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<td></td>
<td>Lecture material will be provided through Moodle.</td>
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</table>

### 3rd Semester: Second Year Compulsory Laboratory Course

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0079-10L</td>
<td>Electronic Circuits Laboratory</td>
<td>O</td>
<td>1 credit</td>
<td>1P</td>
<td>H. Wang</td>
</tr>
<tr>
<td></td>
<td>Lab with principal electronic circuit experiments on the transistor and operational amplifier basis.</td>
<td></td>
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<tr>
<td></td>
<td>Modern, transistor-based electronics has transformed our lives and plays a crucial role in our economy since the 2nd half of last century. The main objective of this course in electronic circuits is to introduce the concept of active device, including operational amplifiers, and their use in amplification, signal conditioning, switching and filtering to students. In addition to gaining experience with typical electronic circuits that are found in common applications, including their own Gruppenarbeit and Fachpraktikum projects, students sharpen their understanding of linear circuits based on nonlinear devices, imperfections of electronic circuits and the concept of design (as opposed to analysis). The course is a prerequisite for higher semester subjects such as analog integrated circuits, RF circuits for wireless communications, A/D and D/A converters and optoelectronics.</td>
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<tr>
<td></td>
<td>Get to know and understand basic transistor and op amp based electronic circuits. Build and operate simple electronic circuits including supply decoupling. Carry out and understand different, principal measurement methods such as DC- and AC-analysis, time and frequency domain measurements, impedance and transfer function measurements. In the lab we will have a closer look at the following topics and circuits: characterization of a real capacitor including non-idealities; common-emitter transistor amplifier with emitter degeneration; characterization of a real operational amplifier with non-idealities; band pass filter with op amp, resistors and capacitors; data converters; oscillator and function generator based on an op amp.</td>
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</table>

### Laboratory Courses, Projects, Seminars
General Laboratory

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0095-10L</td>
<td>General Laboratory I</td>
<td>W</td>
<td>2 credits</td>
<td>2P</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Enrolment via Online-Tool (EE-Website: Studies -&gt; Bachelor Program -&gt; Third Year -&gt; Laboratory Courses)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The Laboratory courses in the 5th and 6th semesters enable the students to put the the contents of the courses from the four first semesters to the test and to consolidate the acquired knowledge. Furthermore students have the possibility to gain specific knowledge in certain software packages as MATLAB.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Implementing the knowledge acquired during the basic studies.</td>
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<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0096-10L</td>
<td>General Laboratory II</td>
<td>W</td>
<td>4 credits</td>
<td>4P</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Enrolment via Online-Tool (EE-Website: Studies -&gt; Bachelor Program -&gt; Third Year -&gt; Laboratory Courses)</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The Laboratory courses in the 5th and 6th semesters enable the students to put the the contents of the courses from the four first semesters to the test and to consolidate the acquired knowledge. Furthermore students have the possibility to gain specific knowledge in certain software packages as MATLAB.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Implementing the knowledge acquired during the basic studies.</td>
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</table>

Projects & Seminars

Enrolment is only possible for students in the BSc Electrical Engineering and Information Technology from Friday before the start of the semester. Places are allocated using the P&S application tool (https://psapp.ee.ethz.ch/). Please only enroll for P&S for which you apply via the tool.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0085-01L</td>
<td>P&amp;S: Amateur Radio Course</td>
<td>W</td>
<td>1.5 credits</td>
<td>1P</td>
<td>J. Leuthold</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester. The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.</td>
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<tr>
<td>Objective</td>
<td>Der Amateurfunk ermöglicht es, drahlos über weite Distanzen zu kommunizieren. Doch darf eine Amateurfunk-Station nicht ohne Weiternes betrieben werden. Voraussetzung ist das Ablegen der Amateurfunkprüfung HB3 oder HB9 beim BAKOM.</td>
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<td>In diesem Kurs werden wir einen Überblick über die wichtigsten Themengebiete des Amateurfunks bieten. Im praktischen Teil werdet ihr unter anderem die Gelegenheit haben, das Funkgerät selbst in die Hand zu nehmen. In einem Portablen-Ausflug (nicht testatpflichtig) werden wir zudem draussen eine mobile Funkstation aufbauen und betreiben. Nach dem Kurs habt ihr die Möglichkeit, die HB9-Prüfung abzulegen. Mit der Prüfung in der Tasche könnt ihr dann auch die Funkbude des AMIV auf dem ETZ-Dach verwenden oder auch eure eigene Anlage aufbauen und betreiben.</td>
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<td></td>
<td>Voraussetzung für das Test ist eine aktive Teilnahme am Kurs, nicht das Bestehen der BAKOM-Prüfung. Eine erfolgreiche Funkverbindung zu einer anderen Station ist ebenfalls Teil der Testatbedingung. Das Lernmaterial wird in der ersten Kurstunde ausgegeben.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0085-03L</td>
<td>P&amp;S: COMSOL Design Tool – Design of Optical Components</td>
<td>W</td>
<td>3 credits</td>
<td>3P</td>
<td>J. Leuthold</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester. The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.</td>
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</tr>
<tr>
<td>Abstract</td>
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</tr>
<tr>
<td>Objective</td>
<td>Simulation tools are becoming an essential accessory for scientists and engineers for the development of new devices and study of physical phenomena. More and more disciplines rely on accurate simulation tools to get insight and also to accurately design novel devices. COMSOL is a powerful multiphysics simulation tool. It is used for a wide range of fields, including electromagnetics, semiconductors, thermodynamics and mechanics. In this P&amp;S we will focus on the rapidly growing field of integrated photonics. During hands-on exercises, you will learn how to accurately model and simulate various optical devices, which enables high-speed optical communication. At the end of the course, students will gain practical experience in simulating photonic components by picking a small project in which certain photonic devices will be optimized to achieve required specifications. These simulated devices find applications in Photonic Integrated Circuits (PICs) on chip-scale.</td>
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<tr>
<td></td>
<td>Course website: <a href="https://blogs.ethz.ch/ps_comsol">https://blogs.ethz.ch/ps_comsol</a></td>
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<tr>
<td>Prerequisites / notice</td>
<td>No previous knowledge of simulation tools is required. A basic understanding of electromagnetics is helpful but not mandatory. The course will be taught in English.</td>
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</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0085-04L</td>
<td>P&amp;S: Microcontrollers for Sensors and the Internet of Things</td>
<td>W</td>
<td>4 credits</td>
<td>4P</td>
<td>P. Mayer, M. Magno</td>
</tr>
<tr>
<td></td>
<td>The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.</td>
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</tbody>
</table>
### P&S: FPGA in Quantum Computing with Superconducting Qubits

**Objective**

Microprocessors are used to execute extensive and generic applications. In contrast to that, microcontrollers (MCUs) are low-cost and low-power embedded chips with program memory and data memory built into the device. They are widely used to execute simple tasks within one specific application domain (i.e., sensor devices, wearable systems, and IoT devices). Microcontrollers demand precise and resource-saving programming. Therefore, it is necessary to know the processor architecture, relevant hardware peripherals (clocks, timers, interrupts, ADC, serial interfaces, etc.), and their implementation in the targeted device.

The STM32 family from STMicroelectronics has gained popularity in the industry due to its large product portfolio, solid documentation, and ease of use. This course aims to develop a basic understanding of hard and software concepts for embedded systems and their application in real-world problems. A combination of theory (20%) and practical implementation (80%) should enable students to conduct high-level firmware programming for microcontrollers. Besides programming the MCU, this includes the interaction with analog and digital sensors, data management, on-device processing, and wireless data exchange. More advanced topics, such as hardware-accelerated digital signal processing (DSP), machine learning, and real-time operating systems, will be discussed as part of individual projects if needed. The main programming language will be C.

The course will be taught in English.

<table>
<thead>
<tr>
<th>227-0085-05L</th>
<th>P&amp;S: FPGA in Quantum Computing with Superconducting Qubits</th>
<th>W</th>
<th>3 credits</th>
<th>3P</th>
<th>M. Magno, K. Akin</th>
</tr>
</thead>
</table>

**Approach**

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Abstract**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Objective**

FPGAs are used in wide range of applications including video processing, machine learning, cryptography and radar signal processing, thanks to their flexibility and massive parallel processing power. Recently FPGAs have become important in quantum signal processing where high amount of data should be analyzed in a short time to use quantum advantage and supremacy. In addition, FPGAs are used for quantum state detection and feedback generation, which have to be performed in the scale of hundreds of nanoseconds. The goal of this course is to understand the FPGA based signal processing for superconducting circuits based quantum experiments. The course participants will learn the implementation techniques of the modules for fast quantum signal acquisition and processing, the electronics supporting quantum experiments, and FPGA programming. You will implement quantum signal processing and quantum state detection modules using Xilinx FPGA, Verilog HDL, and high speed ADC. The course will be taught in English. No prior knowledge in quantum physics or FPGA is required, still a good knowledge in any coding language (for example C or Java) is required.

The course will be taught in English.

<table>
<thead>
<tr>
<th>227-0085-06L</th>
<th>P&amp;S: Neural Network on Low Power FPGA: A Practical W</th>
<th>2 credits</th>
<th>2P</th>
<th>M. Magno</th>
</tr>
</thead>
</table>

**Approach**

Does not take place this semester. Repeated enrollment in a later semester is not creditable.

**Abstract**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Objective**

Artificial Intelligence and in particular neural networks are inspired by biological systems, such as the human brain. Through the combination of powerful computing resources and novel architectures for neurons, neural networks have achieved state-of-the-art results in many domains such as computer vision. FPGAs are one of the most powerful platform to implement neural networks as they can handle different algorithms in computing, logic, and memory resources in the same device. Faster performance comparing to competitive implementations as the user can hardcode operations into the hardware. This course will give to the student the basis of Machine Learning to understand how they work and how they can be trained and giving hand-on experiences with the training tools such as Keras. Moreover the course will focus in deploy algorithms in low power FPGA such as the Lattice sensAI platform to have energy efficient running algorithms. The course will provide to the students the tools and know-how to implement neural network on an FPGA, and the student will challenge themself in a 5 weeks practical project that they will present at the end of the course. Experience in FPGA programming is desirable but not mandatory.

The course will be taught in English.

<table>
<thead>
<tr>
<th>227-0085-08L</th>
<th>P&amp;S: Bluetooth Low Energy Programming for IoT</th>
<th>W</th>
<th>3 credits</th>
<th>3P</th>
<th>M. Magno</th>
</tr>
</thead>
</table>

**Approach**

Does not take place this semester. Repeated enrollment in a later semester is not creditable.

**Abstract**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Objective**

Bluetooth Low Energy System on Chip – Firmware Programming and sensors Interfacing using an Arm Cortex-M (Nordic nrf52838) Microcontroller

With the introduction of the BLE 5.0 standard, Bluetooth has achieved high data bandwidth with low power consumption. This makes the technology an ideal match for many applications, i.e., IoT sensor application or audio streaming, by addressing two of the greatest bottlenecks of these devices. This course offers the chance for participants to do hands-on programming of microcontrollers. In particular, the focus will be laid on interfacing with sensors, acquisition of data, on-board event-driven data processing with ARM-Cortex-M processors and BLE or other wireless transmissions. The programming will be performed in C. Today's microcontrollers offer a low power, efficient and cost-effective solution of tackling a nearly infinite number of task-specific applications. Ranging from IoT devices, wearable systems, sensor (mesh) devices, all the way to be integrated as submodules for the most complex system such as cars, planes, and rockets. Microcontrollers derive their advantages from the efficient use of resources and as such require very efficient and resource-saving programming. Therefore, it is mandatory to understand hardware components such as processor cores, ADC, clocks, serial communication, wireless communication, timers, interrupts, etc. The P&S includes five weeks project where the student will setup an IoT sensor node to monitor electric power transmission and distribution system.

The course will be taught in English by the ITET center for project based learning.

<table>
<thead>
<tr>
<th>227-0085-09L</th>
<th>P&amp;S: Spiking Neural Network on Neuromorphic Processors</th>
<th>W</th>
<th>3 credits</th>
<th>3P</th>
<th>G. Indiveri</th>
</tr>
</thead>
</table>

**Approach**

Does not take place this semester. Repeated enrollment in a later semester is not creditable.
Invented in the 1980s in Zurich and awarded with the Kavli prize in 2016, the atomic force microscope (AFM) has enabled us to visualize surfaces at the single atom level, and to measure single molecule and cell-cell interactions, deepening our understanding of material science and biology. This is achieved by controlling micromechanical piezo actuators with nanometer precision and processing noisy signals in order to achieve meaningful data.

In order to introduce you to the capabilities of modern AFMs in biomedical sensing, you will build your own setups in groups of two. You will be introduced to an AFM’s functionality, control, and signal read-out using LabView. A signal of an oscillating tuning-fork will be used as feedback for the self-built AFM. In order to better understand the working principle of a tuning fork, you will also build your own frequency sweeper and analyze it with self-built low-pass filters.

After you have implemented your own setup, you will have the chance to characterize different biomedical samples on state-of-the-art setups. This data will then be analyzed using Python.

The focus of this P&S seminar is to enable you to transfer your theoretical knowledge into practice and at the same time get to know how electrical engineering can be used in biomedical research.

The course requires active participation during the practical sessions, a 10-15 min presentation and a short written report on the acquired results. The course will be given in English.

IMPORTANT: Laptops with WINDOWS are compulsory (because Labview runs NEITHER on Macs NOR on the Macs’ Windows virtual machine).
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

More and sustainable and renewable energy technologies are used for electricity generation to cope with climate change. These distributed resources transform the electric power grid and impose major challenges.

In this seminar, students have the opportunity to glance at cutting-edge research in the field of power systems. Possible research questions might be:

- How to integrate distributed energy generation like PV plants and wind turbines into the electric grid?
- What challenges does the increasing share of electric vehicles and batteries impose on the power grid?
- How to cope for the uncertain generation capacity of renewables and how to forecast it?
- How does the electricity market work and how do the new sources of flexibility transform it?

Students will prepare a presentation and a report on their individual research question, which is based on an assigned paper. The main objectives are to practice literature review, scientific writing and presenting. Students will learn to independently understand specific research results – a crucial skill for academic research including semester and master projects.

The language of instruction is English. Registrations for the seminar are binding.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>227-0085-15L</td>
<td>P&amp;S: Python for Engineers - Get Productive in the Classroom, in the Lab and at Home</td>
<td>3 credits</td>
<td>W</td>
<td>J. Leuthold, D. Rieben</td>
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<tr>
<td>227-0085-16L</td>
<td>P&amp;S: Machine Learning for Brain-Computer Interfaces</td>
<td>3 credits</td>
<td>W</td>
<td>A. Cossettini</td>
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<tr>
<td>227-0085-17L</td>
<td>P&amp;S: Building a Wireless Infrared Headphone</td>
<td>2 credits</td>
<td>W</td>
<td>M. Lerjen</td>
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<tr>
<td>227-0085-18L</td>
<td>P&amp;S: Bits on Air</td>
<td>2 credits</td>
<td>W</td>
<td>M. Lerjen</td>
</tr>
<tr>
<td>227-0085-19L</td>
<td>P&amp;S: Software Defined Radio</td>
<td>3 credits</td>
<td>W</td>
<td>M. Lerjen</td>
</tr>
</tbody>
</table>

This P&S is about the design and operation of an optical infrared audio transmission system. For this purpose, we familiarize ourselves with the basics of the physics of radiation, the marketing and design of semiconductor lasers and photodetectors, and the linear electronics. Each student builds an infrared transmitter and receiver. During assembly, we gain hands-on experience with soldering conventional and SMD components. The finished circuits are tested and tuned and can be taken home afterwards.

The language of instruction is English. Registrations for the seminar are binding.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

The objective is to give insights of signal processing and machine learning applied to brain-computer interfaces to undergraduate students, by having hands-on experience in brain signal acquisition, data processing, feature extraction, and machine learning.

The aim of the Project and Seminars course is to give insights of signal processing and machine learning applied to brain-computer interfaces to undergraduate students, by having hands-on experience in brain signal acquisition, data processing, feature extraction, and machine learning.

Each student builds an infrared transmitter and receiver. During assembly, we gain hands-on experience with soldering conventional and SMD components. The finished circuits are tested and tuned and can be taken home afterwards.

The language of instruction is English. Registrations for the seminar are binding.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Digital communication is a part of our everyday lives, whether we are sending e-mails, watching TV, listening to the radio, or using a cell phone. In this P&S, we will familiarize ourselves with the basics of digital communication.

On conventional PCs, the students will implement their own software modems for data transmission. These modems, just like the digital communication systems used in real life, consist of a modulator, a demodulator and an algorithm to synchronize the carrier of the incoming message. Once implemented, these modems can be used to acoustically transmit any data (such as small text files) between PCs.

We use MATLAB but previous knowledge thereof is not assumed. Rather, the goal of the project is to practice programming with MATLAB in addition to learning basic knowledge of digital communication.

The language of instruction is English. Registrations for the seminar are binding.
### P&S: Quad-Rotors: Control and Estimation

**Objective**
The first half of the P&S will introduce the physical model for a quad-rotor and use this to apply the control and estimation techniques that are taught in the 5th semester in the Control Systems 1 (CS1) class. The students will then create their own control functions for a quad-rotor and test these in simulation. In the second half of the course the students will implement the control and estimation algorithms they design in the real-world on our fleet of nano-quad-rotors. Once stable flight is achieved, the students will have the freedom to perform tasks with the quad-rotor. By implementing the control and estimation algorithms on a real quad-rotor, the students will gain experience in how decisions in the modelling and design stage affect real-world performance.

**Content**
The simulations will be coded in MATLAB, and the real-world implementation in C++.

**Competencies**
- **Subject-specific Competencies**: Techniques and Technologies
- **Method-specific Competencies**: Problem-solving
- **Social Competencies**: Adaptability and Flexibility
- **Personal Competencies**: Critical Thinking

**Prerequisites / notice**
- Important Information:
  - Students must be in the 5th semester.
  - The first class will be on Wednesday, September 27 for all students.
  - Classes will then occur every second week. The students will be split into two groups and the classes for each group will occur on alternating weeks.
  - It is preferable to be taking the Control Systems 1 (CS1) course but not mandatory. Those students who are not taking CS1 will need to complete some extra reading to understand some aspects of this P&S. The simulations will be coded in MATLAB, and the real-world implementation in C++.

**Schedule**
- The course is taught in English and is open to 5th or higher-semester students. Prior exposure to control theory (e.g., by attending a Control Systems course) is desirable but not required. Students who are not familiar with control theory will need some extra study to understand some aspects of this P&S course.

**Details**
- A video showing how we adapted to the online setting for COVID-19 can be seen here: https://www.youtube.com/watch?v=nHcfb3OprB
- A video showing highlights from HS2018 can be seen here: https://www.youtube.com/watch?v=PEg-XHSXd58
- Details of this P&S course can be found at: https://www.dfall.ethz.ch/pands.php

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### P&S: RoboCup: Learning and Control

**Objective**
RoboCup is a tournament where teams of autonomous robots compete in soccer matches against each other. The ETH team NomadZ (https://robotcup.ethz.ch/) plays in the Standard Platform League with a team of humanoid NAO robots. The focus lies on developing robust and efficient algorithms for vision, control, and behavior.

**Abstract**
The main objective of this course is for students to become familiar with theoretical aspects currently in the spotlight of RoboCup. This is accomplished by a combination of theory sessions, related student exercise sets and programming projects in MATLAB, Python, and C++.

**Prerequisites / notice**
- Important information for candidates:
  - You are required to bring your own Laptop for the programming exercises. A basic knowledge of programming in MATLAB, Python, and C++ is required.
  - The course is taught in English and is open to 5th or higher-semester students. Prior exposure to control theory (e.g., by attending a Control Systems course) is desirable but not required. Students who are not familiar with control theory will need some extra study to understand some aspects of this P&S course.

**Schedule**
- The topics cover fundamental topics on data-driven learning and control.

**Competencies**
- **Subject-specific Competencies**: Concepts and Theories
- **Techniques and Technologies**: assessed

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### P&S: Magnetic Resonance: From Spectrum to Image

**Objective**
The phenomenon of nuclear magnetic resonance (NMR) and its application for spectroscopy and imaging are introduced. The course starts with a general introduction to NMR, followed by measurements on a clinical MRI scanner. The NMR experiments will be developed and programmed by the students. Starting from a simple spectroscopic experiment, the basics of imaging will be acquired step-by-step. Finally, sectional images of test objects will be obtained.

**Abstract**
In this P&S we will take a closer look at how SDR works. In the first part we will work on the basics of frequencies, spectra, modulation types, and signal processing.

**Prerequisites / notice**
- The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Schedule**
- A video showing how we adapted to the online setting for COVID-19 can be seen here: https://www.youtube.com/watch?v=nHcfb3OprB
- A video showing highlights from HS2018 can be seen here: https://www.youtube.com/watch?v=PEg-XHSXd58

**Competencies**
- **Subject-specific Competencies**: Knowledge and Application
- **Techniques and Technologies**: assessed

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### P&S: Biosignal Acquisition and Processing for IoT

**Objective**
Wireless transmission of information is ubiquitous today. Depending on application and frequency range, different types of modulation are used, with digital methods having largely replaced the old analog methods. Software Defined Radio (SDR) tools make it possible to dive into this world and "surf the waves" with relatively little effort. More powerful computers allow for increasingly complex signal processing in transmitters and receivers. At the same time, the signal processing algorithms can be adapted and changed very quickly and flexibly.

**Abstract**
In this P&S we will take a closer look at how SDR works. In the first part we will work on the basics of frequencies, spectra, modulation types, and signal processing.

**Prerequisites / notice**
- The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Schedule**
- A video showing how we adapted to the online setting for COVID-19 can be seen here: https://www.youtube.com/watch?v=nHcfb3OprB
- A video showing highlights from HS2018 can be seen here: https://www.youtube.com/watch?v=PEg-XHSXd58

**Competencies**
- **Subject-specific Competencies**: Knowledge and Application
- **Techniques and Technologies**: assessed
The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

### Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

### Objective

Biosignal acquisition and processing – Wearable sensor node design and analysis for bio-impedance sensor using an Arm Cortex-M

(Nordic nrf52838) Microcontroller

Wearable smart sensor electronics has the potential to revolutionize the medical field. Various body conformal flexible sensors have been used to monitor motion and physiological electrical signals such as electrocardiography (ECG), electroencephalography (EEG) and body composition analysis via body bio-impedance measurements. Smart sensor nodes not only provide accurate and continuous data in time but also automate the process of maintaining medical records, thereby lowering the workload of the health worker or clinician. This course offers an avenue for the students to understand the interdisciplinary principles that make it possible to interpret human physiology by utilizing discreet electronic components. Most importantly, participants will get a chance to do hands-on system design specific to electronically tracking a particular physiological phenomenon. In particular, the focus will be laid on programming of micro controllers, interfacing with sensors, acquisition of data and utilizing discreet analog elements for bio-signal processing. The programming will be performed in C.

The course will be taught in English and by the ITET center for project based learning.

### 227-0085-27L

**P&S: Android Application Development (AAD)**

*W* 4 credits 3P  M. Magno

Does not take place this semester.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Abstract**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Objective**


Although the App-Industry is dominated by the giant Apps right now, it is still crucial that one knows how those Apps function and how those Apps are communicating with their hardware. This course offers the opportunity for the participants to understand the development of application using Android Studio. Most importantly, participants will get a chance to do hands-on software design specific to Android smartphone and the data acquisition from sensors, GPS, google maps and other internal devices. The main goal of the course if providing the students with the basic principle and software programming for build up every android application. The course include 4-5 weeks project were the students alone or in group will build up a working demo of a target application. The course will conclude with the presentation of the students work. Previous experience in C/Java or other languages is preferable but not mandatory. The students will program their own Android Smartphone.

The course will be taught in English by the new Project-based learning centre.

### 227-0085-28L

**P&S: iCEBreaker FPGA For IoT Sensing Systems**

*W* 3 credits 3P  M. Magno, C. Vogt

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Abstract**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Objective**

Ultra Low Lattice FPGA – High Level Programming – Peripherals Interfacing using an Lattice FPGA

Field-programmable gate array (FPGA) is an integrated circuit designed to be configured by a customer or a designer after manufacturing, so they are also "field-programmable". The FPGA configuration is generally specified using a hardware description language (HDL), similar to that used for an application-specific integrated circuit (ASIC). However more and more nowadays producers and open source community are providing higher level tools to program them similiar than processors. On the other side still it is important know the hardware architectures. This course will give to the students the opportunity to program FPGA in a high level way and use them to connect with external peripherals such as display, sensors, etc. In particular, the course will use the iCEBreaker FPGA boards that is specifically designed for students and engineers. They work out of the box with the latest open source FPGA development tools and next-generation open CPU architectures. The course will also iCEBreaker can be expandable through its Pmod connectors, so the students can make use of a large selection of third-party modules. The course will include a project where the students will learn how to build a full working system for the next generation of Internet of Things intelligent smart sensing.

The course will be taught in English by the new D-ITET center for Project-based learning.

### 227-0085-29L

**P&S: Embedded Deep Learning with Huawei Atlas 200**

*W* 3 credits 3P  M. Magno

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Abstract**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
Objective

Deep learning networks (DNNs) have become the leading method for a wide range of data analytics tasks, after a series of major victories at the ImageNet Large Scale Visual Recognition Challenge (ILSVRC). For ILSVRC, the task was to classify images into 1000 different classes, many of which are difficult to distinguish (e.g., many classes are different breeds of dogs). All that was given were 1.2 million labelled images. Meanwhile, this recipe for success has taken over many more areas, from image-based tasks like segmenting objects in images, detecting objects, enhancing images using super-resolution and compression artifact reduction, to robotics and reinforcement learning, and a wide range of industrial applications.

DNNs and their subtype convolutional neural networks (CNNs) have not been new in the 2013 when the wave of success has started, but they got this huge boost through the new availability of large-scale dataset and—at least as importantly—the availability of the necessary compute resources by using GPUs to perform the computations required during training.

While GPUs were then also used to stem the high computation effort of DNNs during inference (e.g. classifying images directly using a trained DNN rather than training the DNN itself). The high demand, the need for cost efficiency, and the goal of deploying DNNs not just in data centers but pervasively in everyday devices, wearables, and low-latency industrial or interactive applications, has triggered the development of various application-specific processors which are much faster, vastly more energy efficient, and cheaper at the same time—such as the Google TPU, Graphcore, …, and Huawei’s Ascend/Atlas platforms.

In this course, you will learn:
1) the basics of deep neural networks, how they work, and what challenges there are for inference,
2) how platforms with specialized hardware accelerators, specifically the Huawei Atlas 200, can be used for running DNN inference and getting a practical application running, and
3) work on your own project using DNNs and hardware accelerators based on your own ideas or on some of our proposals.

The course will be taught in English by the new D-ITET center for Project-Based Learning and a special guest lecturer from Huawei. Individual interactions/help can also be in (Swiss) German.

Most sessions will be around 1 hour of lecture and 2 hours of practical computer exercises. We will start an introduction and then you will have ca. 8 weeks to work on your project, which will concluded with a final presentation of your results.

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### 227-0085-31L P&S: Vision Goes Vegas ★

Does not take place this semester.

**Objective**

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Abstract**

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

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### 227-0085-32L P&S: Magnetic Fields in Our Daily Life ★

**Objective**

Computer Vision beschäftigt sich unter anderem damit, Maschinen zu befähigen ihre Umwelt zu sehen und das wahrgenommene Bild zu verstehen. In unserem Projekt soll ein System entwickelt werden, das Spielkarten erkennen kann und, einer guten Strategie folgend, erfolgreich Black-Jack spielen kann. Die Teilnehmer des Projektes werden kleine Teams bilden und gemeinsam mit einem Assistenten die Aufgabe erarbeiten und eine Implementierung erstellen. Am Ende des Semesters sollen die Programme im öffentlichen Wettstreit gegeneinander antreten!


Als Voraussetzungen sollte Interesse an Computer Vision mitgebracht werden und die Bereitschaft, sich in einem Team von Mitsstudierenden einzubringen. Kenntnisse in C++ sind notwendig.

Der Kurs wird von Prof. Fisher Yu mitbegutachtet.

Dieses P&S wird in englischer Sprache durchgeführt.

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### 227-0085-33L P&S: Accelerating Genome Analysis with FPGAs, GPUs, and New Execution Paradigms ★

**Objective**

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

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Objective
Genome analysis is a cornerstone for groundbreaking scientific and medical advancements, including personalized healthcare. However, the field faces significant computational challenges, such as algorithmic bottlenecks and the handling of large datasets. This course aims to provide a comprehensive understanding of these computational facets, spanning across the computing stack from algorithms, software & tools, to microarchitecture & hardware accelerators.

The course will cover how advanced hardware solutions like FPGAs and GPUs can expedite genome analysis by reducing computational time and energy consumption. In parallel, it will delve into the use and development of heuristic algorithms & tools for accelerating genome analysis across various computational platforms. These algorithms, for example, can offer tradeoffs between computational intensity and accuracy. Students will engage in hands-on projects focused on optimizing existing methods or innovating new solutions for genome analysis. The curriculum’s dual emphasis on hardware solutions and versatile algorithmic strategies offers students a holistic view of the current challenges and potential resolutions within the realm of genome analysis.

The course is conducted in English.

Course website: https://safari.ethz.ch/projects_and_seminars/doku.php?id=bioinformatics

Content
The students carry out a hands-on project under the supervision of their mentors. We also offer the following lectures that the students are encouraged to follow to make impactful progress on their projects.

Lecture 1a: P&S Course Introduction & Scope
Lecture 1b: Project Overview and Q&A
Lecture 2: Introduction to Genome Analysis
Lecture 3: From Molecules to Data: An Overview of DNA Sequencing Technologies
Lecture 4a: Fundamentals of Sequence Alignment: Algorithms and Applications
Lecture 4b: Optimizing Sequence Search: Hashing, Indexing, and Filtering Techniques
Lecture 5a: Building the Blueprint of Life: Genome Assembly
Lecture 5b: Generating Insights from Genome Analysis: Variant Calling and Functional Genomics
Lecture 6a: GateKeeper
Lecture 6b: SneakySnake
Lecture 6c: GRIM-Filter
Lecture 7a: GenASM
Lecture 7b: Scrooge
Lecture 8: SeGraM
Lecture 9: GenStore
Lecture 10a: GenPIP
Lecture 10b: TargetCall
Lecture 11a: BLEND
Lecture 11b: AirLift
Lecture 12a: Raw Nanopore Signal Analysis & RawHash

Lecture notes
See: https://safari.ethz.ch/projects_and_seminars/doku.php?id=bioinformatics

Literature
Learning Materials
===============
1. Overview paper on co-designing hardware and software for genome analysis: https://people.inf.ethz.ch/omutlu/pub/AcceleratingGenomeAnalysis_dac23.pdf
2. Survey on the main steps in the genome analysis pipeline and their bottlenecks: https://people.inf.ethz.ch/omutlu/pub/IntelligentGenomeAnalysis_csbj22.pdf
5. Example of accelerating genomic sequence matching with FPGAs or GPUs: https://people.inf.ethz.ch/omutlu/pub/SneakySnake_UniversalGenomePrealignmentFilter_bioinformatics20.pdf
7. Examples of software/hardware co-design for genomic sequence matching:

Prerequisites / notice
- No prior knowledge in bioinformatics or genome analysis is required.
- An interest in optimizing efficiency and solving complex problems is essential.
- Basic to good knowledge in C or C++ programming language is required.
- Previous coursework in Digital Design and Computer Architecture, or an equivalent course, is desirable.
- Experience in either FPGA implementation, GPU programming, or algorithm design is highly beneficial but not mandatory.
The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allowing for explorative learning and teaching the methodology of project work.

Objective
DRAM is predominantly used to build the main memory systems of modern computing devices. Emerging memory technologies (RRAM, PCM, STT-MRAM, FeRAM) provide an exciting opportunity to replace or complement DRAM. Simulation-based experimental studies are key for understanding the complex interactions between DRAM, emerging memory technologies, and modern applications. Ramulator is an extensible main memory simulator providing cycle-accurate performance models for a variety of commercial DRAM standards (e.g., DDR3/4, LPDDR3/4, GDDR5, HBM), emerging memory technologies, and academic proposals. Ramulator has a modular design that enables easy integration of additional standards, technologies and mechanisms. Ramulator is written in C++11 and can be easily integrated to full-system simulators such as gem5.

In this P&S, you will design new memory and memory controller mechanisms for improving overall system performance, energy consumption, reliability, security, scalability and cost. You will extend Ramulator with these new designs and evaluate their performance, energy consumption, and reliability using modern applications. This will be the right P&S for you if you would like to learn about the state-of-the-art and future memory and memory controller designs and their interaction with modern applications.

This P&S will also enable you to hands-on simulate and understand the memory system behavior of modern workloads such as machine learning, graph analytics, and genome analysis.

The course is conducted in English.

Lecture notes
See https://safari.ethz.ch/projects_and_seminars/doku.php?id=ramulator

Learning Materials
An old version of Ramulator:
https://github.com/CMU-SAFARI/ramulator

Original Ramulator paper:

An example study of modern workloads and DRAM architectures using Ramulator:

An example recent study of a new DRAM architecture using Ramulator:

An example recent study of a new virtual memory system architecture using Ramulator:

Several examples of new ideas enabled by Ramulator based evaluation

Prerequisites
A good knowledge of modern C++ is mandatory for this course. We do not teach basic programming in this course. If your skills are not adequate, it is unlikely you will be able to complete the project work and pass the course. We will hand out a mandatory assignment in the first week of the course where you are asked to complete basic tasks (e.g., building the executable, navigating through the source code, writing a simple extension to Ramulator 2.0) to make sure you are equipped with the necessary skills. If you are unable to complete these tasks in the first week, it is unlikely you will be able to complete the project work and pass the course.

Competencies

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<tr>
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<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<tbody>
<tr>
<td></td>
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<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
<td>Self-awareness and Self-reflection</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 946 of 2667
DRAM is predominantly used to build the main memory systems of modern computing devices. To improve the performance, reliability, and security of DRAM, it is critical to perform experimental characterization and analysis of existing cutting-edge DRAM chips.

DRAM Bender is an FPGA-based DRAM testing infrastructure that enables the programmer to perform all low-level DRAM operations (i.e., DDR commands) in a cycle-accurate manner. DRAM Bender provides a simple and intuitive high-level programming interface (in C++ and Python) that completely hides the low-level details of the FPGA from programmers. Programmers implement test routines in C++, and the test routines automatically get translated into the low-level memory controller operations in the FPGA. DRAM Bender developers write low-level hardware description language code to enable new and faster studies.

In this P&S, you will have the chance to learn how DRAM is organized and operates in a low-level and gain practical experience in using DRAM Bender while developing SoftMC programs for new DRAM characterization studies related to performance, reliability, and security. You may also improve the FPGA-based testing infrastructure itself to enable new studies. And, who knows, you might discover new security vulnerabilities like RowHammer and RowPress.

This will be the right P&S for you if you are interested in DRAM technology and would like to learn more about it as well as FPGA technology and how it can be used for practical purposes such as understanding and mitigating RowHammer attacks, generating true random numbers, reducing memory latency, fingerprinting and identifying devices, and improving reliability.

The course is conducted in English.

Course website: https://safari.ethz.ch/projects_and_seminars/doku.php?id=softmc
Lecture notes See: https://safari.ethz.ch/projects_and_seminars/doku.php?id=softmc
Literature Learning Materials:

- DRAM Bender open source repository: https://github.com/CMU-SAFARI/DRAM-Bender
- An old version (SoftMC) of DRAM Bender is here: https://github.com/CMU-SAFARI/SoftMC
- SoftMC lecture: https://www.youtube.com/watch?v=tnSPEP3t-Ys
- Example security attack study using SoftMC: Link
- Example neural network acceleration study using SoftMC: Link
- Example random number generation study using SoftMC: Link
- Example physical unclonable function study using SoftMC: Link
- Example neural network acceleration study using SoftMC: Link
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- Example random number generation study using SoftMC: Link
- Example physical unclonable function study using SoftMC: Link
- Example neural network acceleration study using SoftMC: Link

Prerequisites / notice

A good knowledge of modern C++ is mandatory for this course. We do not teach basic programming in this course. If your skills are not adequate, it is unlikely you will be able to complete the project work and pass the course. We will hand out a mandatory assignment in the first week of the course where you are asked to complete basic tasks (e.g., building the executable, navigating through the source code, writing a simple extension to Ramulator 2.0) to make sure you are equipped with the necessary skills. If you are unable to complete these tasks in the first week, it is unlikely you will be able to complete the project work and pass the course.

- Digital Circuits (or equivalent course) AND Computer Engineering
- Good knowledge of modern C++ and common Linux tools (e.g., git, ssh, and gcc)
- Interest in low-level system exploration and memory
- Interest in discovering why things do or do not work and solving problems

Competencies

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<td>Techniques and Technologies</td>
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Prerequisites of the course:

A good knowledge of modern C++ is mandatory for this course. We do not teach basic programming in this course. If your skills are not adequate, it is unlikely you will be able to complete the project work and pass the course. We will hand out a mandatory assignment in the first week of the course where you are asked to complete basic tasks (e.g., building the executable, navigating through the source code, writing a simple extension to Ramulator 2.0) to make sure you are equipped with the necessary skills. If you are unable to complete these tasks in the first week, it is unlikely you will be able to complete the project work and pass the course.

- Digital Circuits (or equivalent course) AND Computer Engineering
- Good knowledge of modern C++ and common Linux tools (e.g., git, ssh, and gcc)
- Interest in low-level system exploration and memory
- Interest in discovering why things do or do not work and solving problems

P&S: Genome Sequencing on Mobile Devices

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
Genome analysis is the foundation of many scientific and medical discoveries, and serves as a key enabler of personalized medicine. This analysis is currently limited by the inability of existing technologies to read an organism’s complete genome. Instead, a dedicated machine (called sequencer) extracts a large number of shorter random fragments of an organism’s DNA sequence, known as reads. Small, handheld sequencers such as ONT MinION and Flongle make it possible to sequence bacterial and viral genomes in the field, thus facilitating disease outbreak analyses such as COVID-19, Ebola, and Zika. However, large, capable computers are still needed to perform genome assembly, which tries to reassemble read fragments back into an entire genome sequence. This limits the benefits of mobile sequencing and may pose problems in rapid diagnosis of infectious diseases, tracking outbreaks, and near-patient testing. The problem is exacerbated in developing countries and during crises where access to the internet network, cloud services, or data centers is even more limited.

In this course, we will cover the basics of genome analysis to understand the speed-accuracy tradeoff in using computationally-lightweight heuristics versus accurate computationally-expensive algorithms. Such heuristic algorithms typically operate on a smaller dataset that can fit in the memory of today’s mobile device. Students will experimentally evaluate different heuristic algorithms and observe their effect on the end results. This evaluation will give the students the chance to carry out a hands-on project to implement one or more of these heuristic algorithms in their smartphones and help the society by enabling on-site analysis of genomic data.

The course is conducted in English.

Course website: https://safari.ethz.ch/projects_and_seminars/doku.php?id=genome_seq_mobile

Lecture notes
See: https://safari.ethz.ch/projects_and_seminars/doku.php?id=genome_seq_mobile

Literature
Learning Materials
===============
3. An example of how to accelerate genomic sequence matching by two orders of magnitude with the help of FPGAs or GPUs: https://arxiv.org/abs/1910.09020
5. An example of using a different computing paradigm for accelerating read mapping step and improving its energy consumption: https://arxiv.org/pdf/1708.04329
7. An example of a purely software method for fast genome sequence analysis: http://www.biomedcentral.com/content/pdf/1471-2164-14-S1-S13.pdf
9. Accelerating Genome Analysis, Invited Talk BSC, Onur Mutlu: https://www.youtube.com/watch?v=tVpg0XqU_c4

Prerequisites / notice
Prerequisites of the course:
- No prior knowledge in bioinformatics or genome analysis is required.
- A good knowledge in C programming language and programming is required.
- Interest in making things efficient and solving problems

Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Problem-solving assessed
Project Management assessed
Communication assessed
Cooperation and Teamwork assessed
Leadership and Responsibility assessed
Adaptability and Flexibility assessed
Critical Thinking assessed
Self-direction and Self-management assessed

Abstract
The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
Data movement between the memory units and the compute units of current computing systems is a major performance and energy bottleneck. For example, data movement between the main memory and the processing cores accounts for 62% of the total system energy in consumer applications. As a result, the data movement bottleneck is a huge burden that greatly limits the energy efficiency and performance of modern computing systems. This phenomenon is an undesired effect of the dichotomy between memory and the processor, which leads to the data movement bottleneck.

Many modern and important workloads such as machine learning, computational biology, graph processing, databases, video analytics, and real-time data analytics suffer greatly from the data movement bottleneck. These workloads are exemplified by irregular memory accesses, relatively low data reuse, low cache line utilization, low arithmetic intensity (i.e., ratio of operations per accessed byte), and large datasets that greatly exceed the main memory size. The computation in these workloads cannot usually compensate for the data movement costs. In order to alleviate this data movement bottleneck, we need a paradigm shift from the traditional processor-centric design, where all computation takes place in the compute units, to a more data-centric design where processing elements are placed closer to or inside where the data resides. This paradigm of computing is known as Processing-in-Memory (PIM).

This is your perfect P&S if you want to become familiar with the main PIM technologies, which represent “the next big thing” in Computer Architecture. You will work hands-on with the first real-world PIM architecture, will explore different PIM architectures for important workloads, and will develop tools to enable research of future PIM systems. Projects in this course span software and hardware as well as the software/hardware interface. You can potentially work on developing and optimizing new workloads for the first real-world PIM hardware or explore new PIM designs in simulators, or do something else that can forward our understanding of the PIM paradigm.

Prerequisites of the course:
- Digital Circuits AND Computer Engineering (or equivalent courses)
- Familiarity with C/C++ programming.
- Interest in future computer architectures and computing paradigms.
- Interest in discovering why things do or do not work and solving problems
- Interest in making systems efficient and usable

The course is conducted in English. The course has two main parts:
1. Weekly lectures on processing-in-memory.
2. Hands-on project: Each student develops his/her own project.

Lecture notes

See: https://safari.ethz.ch/projects_and_seminars/

Literature

Learning materials

Summary papers about recent research in PIM.

An analysis of a real-world processing in memory architecture.

Repository: https://github.com/CMU-SAFARI/prim-benchmarks

PIM Simulators.
Ramulator-PIM: A version of Ramulator simulator for PIM.
https://github.com/CMU-SAFARI/ramulator-pim
DAMOV simulator.
https://github.com/CMU-SAFARI/DAMOV

UPMEM SDK documentation: The first real-world PIM architecture.
https://sdk.upmem.com/2023.1.0/

An example recent study of 3D-stacked PIM for consumer workloads.

An example recent study of lightweight PIM functionality on 3D-stacked memory.

An example recent study of a PIM accelerator for graph processing.
https://people.inf.ethz.ch/omutlu/pub/tesseract-pim-architecture-for-graph-processing_isca15.pdf

An example recent study of a Processing-in-Using-Memory system.

Prerequisites notice

- Digital Circuits AND Computer Engineering (or equivalent courses).
- Familiarity with C/C++ programming.
- Interest in future computer architectures and computing paradigms.
- Interest in discovering why things do or do not work and solving problems
- Interest in making systems efficient and usable

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility

Personal Competencies
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

4 credits
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

The way memory and learning is achieved in the brain is an unsolved problem. Due to its relative simplicity, in-vitro neuroscience can help us discover the fundamentals of information processing in the brain. For this we can simulate a small number of biological neurons on top of an array of microelectrodes. Such an approach allows us to simulate the electrical activity of the neurons when they get stimulated.

Following this approach, we can investigate biological neural networks, that have about 5-50 neurons and a controlled network architecture. Still, their behavior remains highly unpredictable. Therefore, it is not yet clear how such networks need to be stimulated electrically in order to control their behavior. However, we can use machine learning to find a mapping between a stimulus and a desired response. More specifically, we can use reinforcement learning, since finding the right stimulation pattern is an instance of the so called multi-armed bandit problem.

This P&S consists of two parts. In the first part we will introduce you to the way neurons can be simulated. You will learn how neurons work and how they communicate. The second part will be about machine learning. We will discuss the basics of both artificial neural networks (ANN) and reinforcement learning. As homework exercises you will implement a reward function for a provided reinforcement learner, which will control your biological networks. In addition you will implement an ANN, that replaces unsatisfactorily performing stimulation patterns with new patterns, that this network evaluates to perform better.

If the current situation will allow, the developed ANNs will be tested on real neurons in our laboratory.

This P&S will be given in English. In total, the P&S takes 8 afternoons and about 50 hours of homework (ANN implementation).

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<tr>
<td>227-0085-39L</td>
<td>P&amp;S: Python for Science &amp; Machine Learning</td>
<td>3</td>
<td>English / German (if necessary)</td>
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<tr>
<td>227-0085-44L</td>
<td>P&amp;S: Understanding and Designing Modern SSDs (Solid-State Drives)</td>
<td>3</td>
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Prerequisites of the course:

- No prior knowledge in NAND flash-based storage systems is required.
- Digital Circuits AND Computer Engineering (or equivalent courses)
- Good knowledge in C/C++ programming language is required.
- Interest in system optimizations

Lecture notes

See: https://safari.ethz.ch/projects_and_seminars/
Literature

Learning Materials

Inside NAND Flash Memories: https://search.library.ethz.ch/permalink/f/823s1o/ELENDING603606

Inside Solid State Drives (SSDs): https://search.library.ethz.ch/permalink/f/823s1o/ELENDING1030264

MQSim, an open-source multi-queue SSD simulator

Source code: https://github.com/CMU-SAFARI/MQSim


Prerequisites /

notice

Prerequisites of the course:
- No prior knowledge of NAND flash-based storage systems is required.
- Digital Circuits AND Computer Engineering (or equivalent courses).
- Good knowledge of C/C++ programming language is required.
- Interest in system optimizations

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed

Personal Competencies
Critical Thinking assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

227-0085-45L P&S: Robotic Maze Solving with a TI-RSLK Robot (RMaze) ■
W 3 credits 3P M. Magno

Does not take place this semester.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Microcontroller programming (C) – Peripherals Interfacing using a MSP433 MCU – Control of a Robot in a maze

The course will focus on teaching how to build and program a Texas Instrument robotic system learning kit (TI-RSLK). It is a robot kit, which includes a 2 wheeled robot, a line sensor to determine lines on the floor as well as sensors to recognize walls. The robot is driven by a MSP432 state of the art ARM Cortex M4 processor.

This course will give the students the opportunity to learn how to program the microcontroller of this robot to navigate in a small maze. For this, the students will learn how to control the motors and, consequently the movement of the robot with the peripherals of the microcontroller. Next to the movement, also the control and readout of the attached sensors will be part of the P&S course.

Once the students are able to read sensor values and control the motors of the robot, this course will conclude with a 4-week project. Within this project the students will design their own algorithm, such that the robot can navigate autonomously within a maze. A small competition at the end of the P&S will find the fastest robot of the group.

The course will be taught in English by the new D-ITET center for Project-based learning, the programming toolchain will be installed on the student’s own laptop. Experience with microcontroller programming (C) is an advantage, however not required. A short introduction will be given during the course.

This course will be taught in English or in German if necessary.

227-0085-46L P&S: Embedded Systems With Drones ■
W 4 credits 4P M. Magno

Does not take place this semester.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
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<td>227-0085-48L</td>
<td>Introduction to Program Nao Robots for Robocup Competition</td>
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<tr>
<td>227-0085-49L</td>
<td>Smart Patch Projects</td>
<td>4</td>
<td>4P</td>
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</table>
Objective

Current MRI scans are limited by patient motion. In clinics, radiologists are often confronted with images with severe motion artefacts in their images. They either have to make a diagnosis although the image artefacts were they could miss crucial information, or they have to send the patient back into the scanner for reacquisition. Such reacquisition might inflict additional costs in the six-figure range per scanner per year.

Further, in research, MRI images from ultra-high field systems are already limited by motion from the cardiobalistic and respiratory movement. Resulting in subpar performance if not addressed appropriately.

The key to overcoming such motion artefacts is estimating the motion and correct for it. Preferably this is done prospective in real-time or otherwise afterwards retrospective in the image reconstruction. Such methods are instrumental in brain imaging since the brain's movement is well described by the rigid body behaviour of the skull.

To do such motion correction, one needs a motion-sensing technology to measure the movement of the human skull with high precision, accuracy and temporal resolution. All this has to be done while being integrated into an MRI machine where powerful static magnetic fields are present, kW of pulsed RF power and MVA of changing magnetic field gradients are present.

In this P&S we explore different motion sensing technologies suitable for deployment in an MRI machine. What you can expect is that we discuss the theory of multiple sensing technologies and then implement an optical, shortwave RF and NMR phase motion sensor. We will spend most of our time in the lab constructing such sensors and testing them on our robotic test bench. Finally, we would also experiment in our MRI facilities, where we would perform motion correction experiments.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

The goal of this P&S is to learn the basics of working with optics and how to assemble optical systems. It is intended to show the practical side to the many optics lectures that are offered at D-ITET.

The course will give a very brief introduction on laser safety, basic building blocks for optics and information on how to handle such elements. The following classes allow the students to test very basics properties of lenses and lasers and how the corresponding optomechanics can be used to arrange a simple setup. After this, the different student groups rotate through four different experiments where they get the chance to build and align different optical setups and perform various measurements. No prior knowledge is required.

227-0085-54L P&S: Optics and Spectroscopy Lab  W  3 credits  4P  J. Leuthold

Does not take place this semester.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

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227-0085-56L P&S: Intelligent Architectures via Hardware/Software  W  3 credits  3P  O. Mutlu

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Modern general-purpose processors are agnostic to an application 19s high-level semantic information. Hence, they employ prediction-based techniques to enable computational and memory optimizations, such as prefetching, cache management policies, memory data placement, instruction scheduling, and many others. As such, the potential of such optimizations is limited due to the limited information the underlying hardware can discover on its own and such optimizations come with large area, power and complexity overheads required by the hardware for prediction purposes. Purely-hardware optimizations cannot achieve their performance potential and waste power, complexity and hardware area, since they are not aware of the application characteristics. On the other hand, purely-software optimizations are fundamentally tied up and limited by the underlying hardware.

A promising way to increase the performance of modern applications is to co-design software and hardware. Hence, lately both industry and academia are making serious attempts to improve performance, energy and security using hardware/software cooperative schemes such as application-specific hardware accelerators (e.g., Google 19s Tensor Processing Unit) and application-specific extensions in general-purpose processors (e.g., Media Engine in Apple M1).

In this course, we will explore several different topics around hardware/software co-design such as: (i) new hardware/software interfaces (e.g., virtual memory, instruction set architecture) to enhance performance, energy and security, (ii) hardware/software co-design schemes to improve the performance of the memory subsystem in killer memory-intensive applications (e.g., sparse and irregular workloads), (iii) hardware/software cooperative machine-learning-based techniques for different microarchitectural components such as prefetchers, caches and branch predictors, which would continuously learn from the vast amount of memory accesses seen by a processor and adapt to the varying workload and system conditions.

If you are enthusiastic about working hands-on to design both software and hardware, this is your P&S. You will have the opportunity to study modern applications, propose software changes to better match the underlying hardware components, design new hardware components that better match the overlying software and come up with new machine-learning techniques to design efficient microarchitectural components. You will also learn how to program industry-supported microarchitectural simulators and study the performance of modern workloads after your hardware/software modifications.

Prerequisites of the course:
- Digital Circuits AND Computer Engineering (or equivalent courses)
- Familiarity with C/C++ programming and strong coding skills.
- Interest in future computer architectures and computing paradigms.
- Interest in discovering why things do or do not work and solving problems
- Interest in making systems efficient and usable

Preferable:
- Hands-on experience with Machine Learning frameworks (depends on the topic you choose)

The course is conducted in English.

Lecture notes

See: https://safari.ethz.ch/projects_and_seminars/
The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

Ultrasound is one of the most used medical imaging techniques and it enables many applications, including the monitoring of musculoskeletal activity during movement, the imaging of carotid artery, and the control of prosthetic devices for human-machine interfaces. Recent developments showcased wearable ultrasound probes operating at minimal power consumption, enabling multi-day continuous monitoring of physiological parameters, and many companies and research centers are actively working on the development of the next generation of truly-wearable ultrasound for a number of monitoring and diagnostics applications.

To sustain such recent developments, it is important to be familiar with all sub-components (hardware and software) of such biomedical systems.

The goal of this course is the development of the main skills required for successfully developing a wearable ultrasound probe. The students will learn about ultrasound basics, transducer control, signal processing for ultrasound, beamforming and generation of images, microcontroller basics for ultrasound, and practical procedures for performing ultrasound experiments. The course will also introduce the students to Python (applied to ultrasound signal processing) and will include a crash course on Nordic (nRF52 family) microcontrollers. In the final weeks of the course, the students will work on an assigned project.

The course will be taught in English.

Content

Ultrasound is one of the most used medical imaging techniques and it enables many applications, including the monitoring of musculoskeletal activity during movement, the imaging of carotid artery, and the control of prosthetic devices for human-machine interfaces. Recent developments showcased wearable ultrasound probes operating at minimal power consumption, enabling multi-day continuous monitoring of physiological parameters, and many companies and research centers are actively working on the development of the next generation of truly-wearable ultrasound for a number of monitoring and diagnostics applications.

To sustain such recent developments, it is important to be familiar with all sub-components (hardware and software) of such biomedical systems.
Autonomous mobile robotics is a promising field that spans from food delivery robots to the Perseverance Mars rover. In this P&S you will be introduced to the fundamental building blocks of robotics, by hands on experience in the context of the F1TENTH autonomous racing and the Robot Operating System (ROS).

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The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Students learn about various topics such as cryptography, game theory, algorithm design, and Python coding. After attending this course, students will be better equipped to tackle unfamiliar problems - gaining the necessary background and applying the right technical expertise to solve such problems in practice.

The primary programming language will be C. A basic knowledge of Python is suggested but optional. The course will be taught in English.

The kit used in this course is directly provided by STMicroelectronics and can be found here: https://www.st.com/en/evaluation-tools/steval-stwinkt1.html. Combining theory (20%) and practical implementation (80%) should enable students to conduct high-level firmware programming for microcontrollers.

In this practical course, the students will have the opportunity to improve their C programming skills on an actual device, with several general, combining an MCU with sensors, a wireless interface, and onboard signal processing is the foundation for most electronic devices. Microprocessors (MCU) are everywhere today, from ultra-low power wearable devices to robots and embedded systems for the industry. In general, combining an MCU with sensors, a wireless interface, and onboard signal processing is the foundation for most electronic devices. In this practical course, the students will have the opportunity to improve their C programming skills on an actual device, with several sensors (microphones, accelerometers, vibrometers, temperature, humidity), a dual Bluetooth-WiFi wireless interface, and an AI accelerator for onboard data analysis and processing. The kit used in this course is directly provided by STMicroelectronics and can be found here: https://www.st.com/en/evaluation-tools/steval-stwinkt1.html. Combining theory (20%) and practical implementation (80%) should enable students to conduct high-level firmware programming for microcontrollers.

The primary programming language will be C. A basic knowledge of Python is suggested but optional. The course will be taught in English.

The kit used in this course is directly provided by STMicroelectronics and can be found here: https://www.st.com/en/evaluation-tools/steval-stwinkt1.html. Combining theory (20%) and practical implementation (80%) should enable students to conduct high-level firmware programming for microcontrollers.

In this practical course, the students will have the opportunity to improve their C programming skills on an actual device, with several sensors (microphones, accelerometers, vibrometers, temperature, humidity), a dual Bluetooth-WiFi wireless interface, and an AI accelerator for onboard data analysis and processing. The kit used in this course is directly provided by STMicroelectronics and can be found here: https://www.st.com/en/evaluation-tools/steval-stwinkt1.html. Combining theory (20%) and practical implementation (80%) should enable students to conduct high-level firmware programming for microcontrollers.

The primary programming language will be C. A basic knowledge of Python is suggested but optional. The course will be taught in English.

The kit used in this course is directly provided by STMicroelectronics and can be found here: https://www.st.com/en/evaluation-tools/steval-stwinkt1.html. Combining theory (20%) and practical implementation (80%) should enable students to conduct high-level firmware programming for microcontrollers.

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The primary programming language will be C. A basic knowledge of Python is suggested but optional. The course will be taught in English.

The kit used in this course is directly provided by STMicroelectronics and can be found here: https://www.st.com/en/evaluation-tools/steval-stwinkt1.html. Combining theory (20%) and practical implementation (80%) should enable students to conduct high-level firmware programming for microcontrollers.

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The primary programming language will be C. A basic knowledge of Python is suggested but optional. The course will be taught in English.
Objective
Bioinformatics and the computational analysis of next-generation sequencing data are the foundation of many medical discoveries, personalized medicine, high throughput diagnostic techniques, and the early detection of cancer and autoimmune diseases. A dedicated machine (called a sequencer) extracts lots of random fragments of a DNA sequence, known as reads. Small, handheld sequencers such as ONT MinION and Flongle make it possible to sequence bacterial and viral genomes on-site. This enables disease outbreak analyses (i.e., for COVID-19 or Ebola) and the on-site analysis of patient samples. A prominent example is the study of the human microbiome in liquid biopsy samples (i.e., blood samples). The microbiome is strongly related to human health and allows for the early diagnosis of diseases like Parkinson’s, Alzheimer’s, and cancer.

In this course, we will cover the basics of genome analysis for medical applications, high-throughput diagnostics, and the early detection and prevention of diseases.

Students will experimentally evaluate different algorithms and machine-learning techniques to uncover somatic mutations in cancer and develop tools dedicated to microbiome discovery and high-throughput disease diagnostics.

The course is conducted in English.

Content
Course website: https://safari.ethz.ch/projects_and_seminars/fall2024/doku.php?id=clinical_genomics

Prerequisites / notice
- No prior knowledge in bioinformatics or genome analysis is required.
- Proficiency in C/C++ programming and bash scripting is required.
- Interest in clinical applications, human health, and an ambition to make things efficient and to solve new problems.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

| Social Competencies | Communication | assessed |
|                     | Cooperation and Teamwork | assessed |
|                     | Customer Orientation     | assessed |
|                     | Leadership and Responsibility | assessed |
|                     | Self-presentation and Social Influence | assessed |
|                     | Sensitivity to Diversity | assessed |
|                     | Negotiation              | assessed |

| Personal Competencies | Adaptability and Flexibility | assessed |
|                       | Creative Thinking          | assessed |
|                       | Critical Thinking          | assessed |
|                       | Integrity and Work Ethics  | assessed |
|                       | Self-awareness and Self-reflection | assessed |
|                       | Self-direction and Self-management | assessed |

227-0085-68L P&S: Digital Audio

Objective
Real-time digital audio processing on a modern microcontroller

Modern microcontrollers are sufficiently powerful to run real-time audio processing algorithms. Since such microcontrollers can be programmed using a high-level programming language (e.g., C++) and they support floating-point computations, implementation of audio-processing algorithms is quite simple.

In this P&S you will
- learn the basics of digital signal processing (DSP),
- solder a PCB with surface-mount (SMD) components,
- learn to program modern microcontrollers, and
- implement an audio effect (signal processing algorithm) of your choice on a real-time system that you soldered yourself :smile:

There will be a weekly in-person class/exercise session taught by the P&S supervisors (4h per week). In addition, the students will work independently to solder the PCB and to implement their algorithm; this is estimated to take an additional 4h per week.

Prerequisites:
- you play a music instrument and/or have a strong interest in audio processing or music
- you are motivated to work on your project independently in addition to the supervised 4h per week

Group Projects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0091-10L</td>
<td>Group Project I</td>
<td>W</td>
<td>6</td>
<td>5A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract
The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
see above

| 227-0092-10L | Group Project II      | W    | 6    | 5A    | Lecturers |

Abstract
Students must work in groups in supervised projects for 150 to 180 hours minimum. The topics of the group work are open and can be technical of specific nature or more general in the context of engineering.

Objective
see above

Internship in Industry
The internship in industry can only be enrolled for during bachelor's studies according to the 2016 regulations. According to the 2018 regulations, an internship in industry can be taken at master's level.

Please note the conditions for internships in industry as set forward by the "Guidelines for the "Laboratory Courses - Projects - Seminars ", see https://www.ee.ethz.ch/content/dam/ethz/special-interest/itet/department/Studies/Bachelor/Regulations/Richtlinien_Praktika-Projekte-Seminare_v5_final.pdf (German only).

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<tr>
<td>227-0093-10L</td>
<td>Internship in Industry</td>
<td>W</td>
<td>6 credits</td>
<td>external organisers</td>
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</tr>
</tbody>
</table>

**Number**

**Title**

*Only for students in the Bachelor's Programme Electrical Engineering and Information Technology, Regulations 2016. For students enrolled in the 2018 Programme Regulations, see "227-1550-10L Internship in Industry" at Master's level.*

**Abstract**
The main objective of the 12-week internship is to expose bachelor's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

**Objective**

See above.

**Prerequisites / notice**

Please note the conditions for Internships in industry as set forward by the "Guidelines for the "Laboratory Courses - Projects - Seminars ", see https://ethz.ch/content/dam/ethz/special-interest/itet/department/Studies/Bachelor/Regulations/Richtlinien_Praktika-Projekte-Seminare_v5_final.pdf (German only).

**Additional Subjects**

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</thead>
<tbody>
<tr>
<td>227-0651-00L</td>
<td>Applied Circuit and PCB-Design</td>
<td>W</td>
<td>2 credits</td>
<td>4G</td>
<td>A. Blanco Fontao</td>
</tr>
</tbody>
</table>

**Abstract**
The student must motivate the reasons that lead him/her to enroll by means of an e-mail to the person in charge of the course (balfonso@ethz.ch). Failing to do so will result in a registration rejection. Final admission to the course is at the discretion of the lecturer.

**Objective**
The goal is to become acquainted with all those practical aspects of electronic circuit and PCB design by working through a modest but complete application example. This involves analysis of specifications, the evaluation of electronic parts, efficient testing and failure search, electromagnetic compatibility (EMC), the usage of industrial CAE/CAD tools for circuit simulation and PCB layout, generating production data for the board manufacturer, board mounting, testing and start up.

**Content**

- Development - from the idea to the final product
- Analysis of given circuit specifications
- Setting up the Altium Designer environment
- Structure of component libraries
- Preparing schematic symbols for CAE
- Preparing footprints for CAD
- Linking component libraries and databases
- Introduction to Concord Pro and Supply Chain Management
- Structure of schematic diagrams and circuits
- Assigning schematic functions to physical parts
- Capturing a predefined circuit
- Hints for improved testing and failure analysis
- Checking schematic data
- Simulation of mixed-signal circuits using Spice
- Introduction to PCB manufacturing
- Turning circuit schematics into a workable layout using Altium Designer
- Component placement on the PCB
- Manual and automatic interconnect routing
- Design for EMC and High-Speed
- Preparation of production data for the board manufacturer
- Documentation for manufacturing and assembly
- PCB assembly (component mounting and soldering)
- Final circuit testing and start-up.

**Literature**

All necessary documents will be available as electronic documents (PDF).

**Prerequisites / notice**

- The course is recommended to all students who plan to design an electronic circuit or a PCB in an upcoming term project or as part of their master thesis. Attending this course during the term before will ensure they are optimally prepared and will allow them to fully focus on their project.

- The number of participants is limited.

- For their own students and staff, the Department of Information Technology and Electrical Engineering provides electronic components and consumables free of charge. All other participants have to bear a 200 CHF fee for those items.
Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving
Project Management

Social Competencies
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Self-direction and Self-management

5th Semester: Third Year Core Courses

Can be freely combined, a list of recommendations is available under https://ee.ethz.ch/studies/bachelor/third-year/core-courses.html

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<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

Abstract
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content
1. Discrete-time linear systems and filters:
   - state-space realizations, z-transform and spectrum,
   - decimation and interpolation, digital filter design,
   - stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
   - probability, random variables, discrete-time stochastic processes;
   - detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
   - Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes
Lecture Notes

<table>
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<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>L. Josipovic, L. Vanbever, R. Wattenhofer</td>
</tr>
</tbody>
</table>

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by exploring the limits of what is computable and what is not. In doing so, we will consider three distinct models of computation which are often used to model discrete event systems: finite automata, push-down automata and Turing machines (ranked in terms of expressiveness power). In the second part of the course we analyze discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply continuous time markov chains and queueing theory for an understanding of the typical behavior of a system. Then we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queueing. In the last part of the course we introduce methods that allow to formally verify certain properties of Finite Automata and Petri Nets. These are some typical analysis questions we will look at: Do two given systems behave the same? Does a given system behave as intended? Does the system eventually enter a dangerous state?

Content
1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets

Lecture notes
Available at https://disco.ethz.ch/courses/des/
227-0103-00L Control Systems

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective

Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective

Prerequisites / notice

MATLAB is used for system analysis and simulation.

Prerequisites / notice

Literature


Prerequisites / notice

MATLAB is used for system analysis and simulation.

227-0113-00L Power Electronics

W 6 credits 4G J. Huber

Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective

Prerequisites / notice

Prerequisites: Signal and Systems Theory II.

Abstract

Autumn Semester 2024

Data: 02.07.2024 12:39
Content

Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency control current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

Lecture notes

Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites / notice

Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Competencies

Subject-specific Competencies

- Concepts and Theories: fostered
- Techniques and Theories: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Abstract

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:

- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes

Textbook and all further documents in English.

Literature


Prerequisites:

Basics of digital circuits.

Examination:

In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:

https://iis-students.ee.ethz.ch/lectures/vlsi-i/

227-0116-00L VLSI 1: HDL Based Design for FPGAs

W 6 credits 5G F. K. Gürkaynak

227-0121-00L Communication Systems

W 6 credits 4G C. Studer, S. M. Moser
Analytical Competencies

Solid State Electronics and Optics

This lecture focuses on the design of embedded systems using formal models and methods.

After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to:
- understand the fundamentals of digital communication systems
- explain the principles of modulation, demodulation, detection, and error correction
- analyze error rates of simple digital communication systems
- implement simple MATLAB simulations to calculate error rates

The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the
main building blocks of modern digital communication systems. The topics include:
- essential components of digital communication systems
- analog and digital modulation
- baseband and passband representation; up- and down-conversion
- communication channels as LTI systems
- discretizing communication systems; sampling and quantization
- noise, signal-to-noise ratio (SNR), and interference
- detection theory and error rates
- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.

Lecture notes

Lecture notes will be distributed electronically at the beginning of the semester.

Literature


Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Problem-solving assessed

Personal Competencies

Critical Thinking fostered
Integrity and Work Ethics fostered

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>credits</th>
<th>Type</th>
<th>Instructor</th>
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<tr>
<td>227-0124-00L</td>
<td>Embedded Systems</td>
<td>6</td>
<td>G</td>
<td>M. Magno</td>
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<tr>
<td>227-0145-00L</td>
<td>Solid State Electronics and Optics</td>
<td>6</td>
<td>G</td>
<td>N. Yazdani, V. Wood</td>
</tr>
</tbody>
</table>

Abstract

The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and
linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol
interference, detection theory, as well as the basics of forward error correction and information theory.

Objectives

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- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

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Lecture notes

Lecture notes will be distributed electronically at the beginning of the semester.

Literature


Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Problem-solving assessed

Personal Competencies

Critical Thinking fostered
Integrity and Work Ethics fostered

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Lecture notes

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Literature


Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Problem-solving assessed

Personal Competencies

Critical Thinking fostered
Integrity and Work Ethics fostered

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<td>227-0124-00L</td>
<td>Embedded Systems</td>
<td>6</td>
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<td>M. Magno</td>
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<tr>
<td>227-0145-00L</td>
<td>Solid State Electronics and Optics</td>
<td>6</td>
<td>G</td>
<td>N. Yazdani, V. Wood</td>
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<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
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<td>T. Jang</td>
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</table>

**Abstract**

This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

**Objective**

Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

**Content**

Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

**Lecture notes**

Handouts of presented slides. No script but an accompanying textbook is recommended.

**Literature**


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<thead>
<tr>
<th>Course Code</th>
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<th>W Credits</th>
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<th>T Lecturer</th>
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<tr>
<td>227-0311-00L</td>
<td>Qubits, Electrons, Photons</td>
<td>6</td>
<td>3V+2U</td>
<td>T. Zambelli</td>
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</table>

**Abstract**

In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

**Objective**

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electron transfer, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

**IMPORTANT:** “qubits” from the point of view of NMR (and NOT from that of quantum computing!).

**Content**

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

**Lecture notes**

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM, while corresponding videos of the previous years are available in Moodle !!!

**Literature**


Supplementary material will be uploaded in Moodle.

---

**Prerequisites / notice**

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

Biomedical Imaging

Abstract
Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective
Upon completion of the course students are able to:
• Explain the physical and mathematical foundations of diagnostic medical imaging systems
• Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
• Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
• Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Content
• Introduction (intro, overview, history)
• Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
• X-rays (production, tissue interaction, contrast, modular transfer function)
• X-rays (resolution, detection, digital subtraction angiography, Radon transform)
• X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
• Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
• Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
• Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
• Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
• Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
• Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
• Ultrasound (spatial and temporal resolution, phased arrays)
• Ultrasound (Doppler shift, implementations, applications)
• Summary, example exam questions

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011
Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

Bioelectronics and Biosensors

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field
Content

Lecture topics:

1. Introduction

Sources of bioelectronic signals
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

14. Measuring biochemical signals

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics.
In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

5th Semester: Third Year Additional Foundation Courses
Students complete at least two of the Additional Foundation Courses available for selection. Recommendations are available under https://ee.ethz.ch/studies/bachelor/third-year/additional-foundation-courses.html

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<td>227-0014-20L</td>
<td>Computational Thinking</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>R. Wattenhofer</td>
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</tbody>
</table>

Abstract
We learn: algorithmic principles, dynamic and linear programming, complexity, P vs. NP, approximation, reductions, cryptography, zero-knowledge proofs, relational databases, SQL, machine learning, regression, gradient descent, decision trees, deep neural networks, universal approximation, advanced layers and architectures, reinforcement learning, Turing machines, computability, and more.

Objective
Computation is everywhere, but what is computation actually? In this lecture we will discuss the power and limitations of computation. Computational thinking is about understanding machine intelligence: What is computable, and how efficiently?

Understanding computation lies at the heart of many exciting scientific, social and even philosophical developments. Computational thinking is more than programming a computer, it means thinking in abstractions. Consequently, computational thinking has become a fundamental skill for everyone, not just computer scientists. For example, functions which can easily be computed but not inverted are at the heart of understanding data security and privacy. The design of efficient electronic circuits is related to computational complexity. Machine learning on the other hand has given us fascinating new tools to teach machines how to estimate functions. Thanks to clever heuristics, machines now appear to be capable of solving complex cognitive tasks. In this class, we study various problems together with the fundamental theory of computation.

The course uses Python as a programming language. Python is popular and intuitive, a programming language that looks and feels a bit like human instructions. The lecture will feature weekly exercises.

This course follows the flipped classroom paradigm. Students will self-study all important concepts by reading a chapter in the script, and by watching a few short video clips. The class meets every two weeks to answer questions, and for a quiz on the current topic.
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This course follows the flipped classroom paradigm. Students will self-study all important concepts by reading a chapter in the script, and by watching a few short video clips. The class meets every two weeks to answer questions, and for a quiz on the current topic.

The script is available here: https://disco.ethz.ch/courses/coti/

For additional Python programming experience we recommend attending the CodeJam lab: https://disco.ethz.ch/courses/codejam/

For practical deep learning experience we recommend attending the HODL lab: https://disco.ethz.ch/courses/hodl/

For practical deep learning experience we recommend attending the HODL lab: https://disco.ethz.ch/courses/hodl/

227-0053-00L High-Frequency Design Techniques  W  4 credits  2V+2U  C. Bolognesi, T. Popovic

Abstract
Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible: higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Objective
Familiarize students with the essential tools and principles exploited in the high-frequency design. Introduction to circuit simulation. Introduction to amplifier design.

Content
Introduction to wireless, radio spectrum. Review of vectors and complex numbers, AC circuit analysis, matching networks, distributed circuit design, transmission lines and transmission line equations, reflection coefficients, the Smith Chart and its software, voltage standing wave ratio (VSWR), skin effect, matrix analysis, scattering parameters, electromagnetic fields and waves, amplifier design. Hands-on experience with measurement equipment.

Lecture notes
A detailed script is provided for each lecture, including the exercises and their solutions.


227-0122-00L Introduction to Electric Power Transmission: System & Technology  W  4 credits  4G  C. Franck, G. Hug

Abstract
Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible: higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Objective
At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of lines, know about electrical safety, calculate electric withstand strength of gas gaps, stationary power flows and other basic parameters in simple power systems.

Content
Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principles of electric power systems.

Lecture notes
Lecture script in English, exercises and sample solutions.
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<td>Self-direction and Self-management</td>
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### Electives

This is only a small selection. Other courses from the ETH course catalogue may be chosen. Please consult the "Richtlinien zu Projekten, Praktika, Seminare" (German only), https://ethz.ch/content/dam/ethz/special-interest/itet/department/Studies/Bachelor/Regulations/Richtlinien_Praktika-Projekte-Seminare_final_v6.pdf).

### Economics, Law and Management Electives

These subjects are particularly suitable for students planning to apply to the Master's Degree Program in Energy Science and Technology (MSc EST) or Management, Technology and Economics (MSc MTEC).

#### Number Title Type ECTS Hours Lecturers

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>B. Clarysse, S. Brusoni, V. Hoffmann, T. Netland</td>
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<tr>
<td>351-0778-01L</td>
<td>Discovering Management (Pitch)</td>
<td>W</td>
<td>1 credit</td>
<td>1U</td>
<td>B. Clarysse, L. P. T. Vandeweghe</td>
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Abstract

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

Content

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.
the module Discovering Management (351-0778-00L) is mandatory.

Abstract
This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

Objective
The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Content
Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Students have the option to either do this alone or in a group of two students.

Literature
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

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351-0511-00L Managerial Economics
W 4 credits 3V O. Krebs, P. Egger, M. Köthenbürger

Abstract
"Managerial Economics" provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

Objective
The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

Literature

Prerequisites / notice
The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

Competencies

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351-1109-00L Introduction to Microeconomics
W 3 credits 2G M. Wörter, M. Beck

GESS (Science in Perspective):
This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature

Prerequisites / notice
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.
## Competencies

### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

### Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

### Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

## 851-0703-00L Introduction to Law

**W 2 credits 2V O. Streiff Gnöpff**

**Abstract**
This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered. The focus is on legal problems related to space. Active participation is expected in short interactive sequences.

**Objective**
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law. They are able to apply the fundamentals in more advanced law classes and to recognize the relevance of law in their own field.

**Content**
- Basic concepts of law, sources of law.
- Private law: Contract law (particularly contract for work and services), tort law, property law.
- Public law: Human rights, administrative law, procurement law, procedural law.

**Lecture notes**
Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

**Literature**
Further documents will be available online (https://moodle-app2.let.ethz.ch/course/view.php?id=22904).

### Competencies

- Subject-specific Competencies: Concepts and Theories: assessed
- Method-specific Competencies: Analytical Competencies: assessed
- Social Competencies: Sensitivity to Diversity: fostered

## 851-0735-10L Startups and Law

**W 2 credits 2V P. Peyrot**

**Abstract**
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

**Objective**
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

**Lecture notes**
A comprehensive script will be made available online on the moodle platform.

### Competencies

- Subject-specific Competencies: Concepts and Theories: assessed
- Method-specific Competencies: Analytical Competencies: assessed
- Social Competencies: Sensitivity to Diversity: fostered
- Personal Competencies: Adaptability and Flexibility: fostered

## 851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector

**W 2 credits 2V K. Houshang Pour Islam**

**Abstract**
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

### Competencies

- Subject-specific Competencies: Concepts and Theories: assessed
- Method-specific Competencies: Analytical Competencies: assessed
- Social Competencies: Sensitivity to Diversity: fostered
- Personal Competencies: Adaptability and Flexibility: fostered

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**Data: 02.07.2024 12:39**

**Autumn Semester 2024**

**Page 968 of 2667**
Objective  
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice  
The lecture addresses students in the fields of engineering, science and other related technical fields.

Subjects  
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice  
The lecture addresses students in the fields of engineering, science and other related technical fields.

Engineering Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Students master the basic mathematical concepts and algorithms of estimation and machine learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture notes will be handed out as the course progresses.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>solid basics in linear algebra and probability theory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Electromagnetic Waves: Materials, Effects, and Antennas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course provides profound knowledge about electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.</td>
</tr>
<tr>
<td>Objective</td>
<td>You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions. You know how waves interact with matter and about nonlinear, scattering and resonant effects. You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.</td>
</tr>
</tbody>
</table>
| Content       | The lecture covers the following topics:  
|               | • Generic time-harmonic electromagnetic fields  
|               | • Fundamental solutions of the wave equation  
|               | • Wave propagation in various types of materials  
|               | • Interaction of waves with matter  
|               | • Nonlinear effects  
|               | • Resonant effects  
|               | • Applications like scattering, waveguiding, radiation  
|               | • Radio frequency and optical antennas |
| Lecture notes | Lecture notes and slides will be handed out during the lectures. |
| Prerequisites / notice | |
| Competencies  | Subject-specific Competencies: Concepts and Theories assessed  
|               | Techniques and Technologies assessed  
|               | Method-specific Competencies: Analytical Competencies fostered  
|               | Media and Digital Technologies fostered  
|               | Problem-solving fostered  
|               | Social Competencies: Communication fostered  
|               | Personal Competencies: Critical Thinking fostered |

<table>
<thead>
<tr>
<th>Number</th>
<th>Fundamentals of Electric Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.</td>
</tr>
<tr>
<td>Objective</td>
<td>The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.</td>
</tr>
</tbody>
</table>
Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes
- Lecture notes and associated exercises including correct answers

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: fostered

227-0652-00L
Maxwell, Einstein, and the GPS

W 6 credits 2V+2U T. Zambelli

Abstract
Maxwell's equations are reinterpreted in the framework of Einstein's special relativity theory using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

Objective
D-ITET is the depository of the Maxwell's equations, which are dissected from all perspectives in the courses Physics I, Electromagnetic Fields and Waves, and Advanced Electromagnetic Waves.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

Content
- Galileo-Newton, the Ether, Michelson-Morley's Experiment
- Lorentz Transformations
- 4-Vectors in Minkowski's Spacetime: Tensor Formalism
- The Lagrangian, the Principle of Stationary Action for Particles and Fields, Noether's Theorem
- Maxwell’s Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac's Effect
- GPS

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM, while corresponding videos of the previous years are available in Moodle !!!

Literature
• (Special Relativity) L. Susskind and A. Friedman, "Special Relativity and Classical Field Theory: The Theoretical Minimum", 2019, Hachette Book Group USA
• (Lagrangian Formalism) L. Susskind and G. Hrabovsky, "Theoretical Minimum: What You Need to Know to Start Doing Physics", 2014, Hachette Book Group USA

Supplementary material will be uploaded in Moodle.

Prerequisites / notice
- (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA

Furthermore, a solid base of Analysis I & II as well as of Linear Algebra is really helpful.
Competencies | Subject-specific Competencies | Concepts and Theories | assessed
---|---|---|---
| Method-specific Competencies | Techniques and Technologies | fostered
| Social Competencies | Analytical Competencies | assessed
| | Decision-making | assessed
| | Media and Digital Technologies | fostered
| | Problem-solving | assessed
| | Project Management | assessed
| | Communication | fostered
| | Cooperation and Teamwork | fostered
| | Customer Orientation | fostered
| | Leadership and Responsibility | fostered
| | Self-presentation and Social Influence | fostered
| | Sensitivity to Diversity | assessed
| | Negotiation | fostered
| Personal Competencies | Adaptability and Flexibility | assessed
| | Creative Thinking | assessed
| | Critical Thinking | assessed
| | Integrity and Work Ethics | assessed
| | Self-awareness and Self-reflection | assessed
| | Self-direction and Self-management | assessed

227-2211-00L Seminar in Computer Architecture

W 2 credits 2S S. Sadrosadati, Y. Liang, O. Mutlu

Abstract

In this seminar course, we will cover fundamental and cutting-edge research papers in computer architecture. The course will consist of multiple components that are aimed at improving students' technical skills in computer architecture, critical thinking and analysis on computer architecture concepts, as well as technical presentation of concepts and papers in both spoken and written forms.

Objective

The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous presentation and discussion of selected papers during lectures and a written report delivered by each student at the end of the semester. This course is for those interested in computer architecture. Registered students are expected to attend every lecture, participate in the discussion, and create a synthesis report at the end of the course.

Content

Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

See https://safari.ethz.ch/architecture_seminar for past examples.

Lecture notes

All the materials will be posted on the course website: https://safari.ethz.ch/architecture_seminar/

Links to past course materials, including the synthesis report assignment, can be found in this page:
https://safari.ethz.ch/architecture_seminar

Literature

Key papers and articles, on both fundamentals and cutting-edge topics in computer architecture will be provided and discussed. These will be posted on the course website.

See https://safari.ethz.ch/architecture_seminar for past examples.

Prerequisites / notice

Digital Design and Computer Architecture OR Digital Circuits / Computer Engineering

Students should (1) have done very well in Digital Design and Computer Architecture, Digital Circuits or a similar course and (2) show a genuine interest in Computer Architecture.

101-0531-00L Digital Creativity for Circular Construction

W 8 credits 7.5P C. De Wolf

Abstract

The course is about digital innovation towards a circular economy in the built environment. How can we bring together two worlds that are often too distinct: low-impact construction and digital innovation? Bringing digital tools already used in other sectors into the construction sector, students will learn about circular construction (e.g., reuse of materials) through hands-on learning practices.

Objective

In the fall semester 2024 we will focus on applying artificial intelligence (AI) and extended reality (XR) to the circular design workflow and. The course will be taught at the Kunsthalle Zurich as part of an exhibition.

By the end of this course, students will be able to use augmented computational design enabling circular construction, with a view to environmental implications. They will be able to assess the challenges and opportunities of low-carbon, circular construction and evaluate possible solutions using digital technologies to enable a circular built environment (more specifically, with reused building materials). To achieve this, they need to be able to do the following:

1. Apply circular principles using recovered building materials.
2. Compare different digital technologies applied in circular construction (e.g., LiDAR scanning, drone imagery, photogrammetry, computational design, AI, computer vision, XR, LCA tools etc.)
3. Understand the potential and limitations of AI for circular construction, e.g. use machine learning to detect and digitize materials (computer vision) or to support creativity in the early design phases of circular construction (generative AI).
4. Communicate the importance and urgency of circular construction.
5. Assess the environmental impact implications of their design and technology decisions through a preliminary Life Cycle Assessment (LCA).

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 971 of 2667
Nothing works without electronics! Typical products in mechanical engineering such as machine tools, as well as any kind of vehicle contain a significant amount of electric or electronic components of more than 60%. Thus, it is important to master the value added process sequence for electric and electronic components.

The lecture follows the value added process sequence of electric and electronic components. It contains: Development of electric and electronic circuits, design of electronic circuits on printed circuit boards as well as in hybrid technology, integrated test technology, planning of production lines, production of highly integrated electronic on a wafer as well as recycling.

The lecture further describes the manufacturing of integrated circuits, starting from the wafer via the structuring and bonding to the packaging. As an example, the manufacturing of micro-electromechanic and electro-optical systems and actuators is described. Due to similar processes in the electronic production, the value added process sequence for photovoltaics will be described too.

The lecture concludes with an excursion to a large manufacturing company. Here, students can see the application and realization of the manufacturing of electric and electronic devices.
### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### Microsystems I: Process Technology and Integration

**W 6 credits 3V+2U M. Haluska, C. Hierold**

**Abstract**

Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and devices by a sequence of defined processing steps (process flow).

**Objective**

- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

**Content**

Application of selected technologies will be demonstrated on case studies.

**Lecture notes**

Handouts (available online)

**Literature**

- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

**Prerequisites / notice**

Prerequisites: Physics I and II

### Information Systems for Engineers

**W 4 credits 2V+1U G. Fourny**

**Abstract**

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

**Objective**

- Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality.
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.
Content  Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logics

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking

376-0021-00L Materials and Mechanics in Medicine

W 4 credits 3G  M. Zenobi-Wong, J. G. Snedeker

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
Course website on Moodle

Literature

Academic Press

>>> Man-Technology-Environment Electives ("MTU")

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0227-00L</td>
<td>Basics of Air Transport (Aviation I)</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>P. Wild</td>
</tr>
</tbody>
</table>

Abstract
In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics.

Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation.

The program is taught in English and we provide 11 different experts/lecturers.

Objective
The goal is to understand and explain basics, principles and contexts of the broader air transport industry.

Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport.

Ideal foundation for Aviation II - Management of Air Transport.

Content
Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

Concept: This course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

Content: Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Managing; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

Technical visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

Lecture notes
Preparation materials & slides are provided prior to each class

Literature
Literature will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)
402-0368-07L

Lecture Series: Space Research and Exploration

Abstract
Lecture Series about selected topics of space research and exploration consisting of individual talks given by different leading experts from academia and industry.

Objective
Attending students will
- experience the interdisciplinarity of space research and exploration spanning physics, engineering, geosciences, biology and more
- get familiar with the Swiss space research and industry landscape
- enhance their communication skills by broadening their research horizon
- have the opportunity for direct learning by posing questions to experts

Content
The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay between the scientifically desirable and the technologically possible. The 'Lecture Series: Space Research and Exploration' aims to shed light on key questions engaged by leading scientists and engineers today. It consists of weekly lectures, given by different speakers with vast experience in their respective field (e.g., Human Spaceflight, System Engineering of Spacecraft, Space Life Sciences, Space-based astrophysics). Subsequent to the talk, the student will have the opportunity to deepen their understanding by asking questions to the presenter in a moderated Q&A.

Confirmed speakers will be announced by the start of the semester (see lecture from last year for previous speakers).

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Sensitivity to Diversity

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking

Science in Perspective

Only courses offered under "GESS Science in Perspective" count in this category. See "Offered in" tab in course view. For more information, please refer to https://gess.ethz.ch/en/studies/science-in-perspective/SiP-FAQs.html

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ITET

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Bachelor's Project

The Bachelor's Thesis is the final part of the bachelor's program and should therefore only be taken in the semester in which the bachelor's diploma is acquired.

The minimum requirement for enrollment is the successful completion of:
- basic examination (examination blocks A+B) and
- subjects of the second year (examination blocks 1-3)

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
227-0100-00L | Bachelor's Thesis | O | 12 credits | 26D | Supervisors

Abstract
A 14 week long Bachelor's Thesis is the final part of the bachelor's program and shall therefore be taken during the semester in which the bachelor's diploma is acquired.

The minimum requirement for enrollment is the successful completion of:
- basic examination (examination blocks A+B) and
- subjects of the second year (examination blocks 1-3)

Supervisor must be a professor at D-ITET or associated, see a link to the lists of those at https://ee.ethz.ch/studies/bachelor/third-year/bachelor-project.html

During the Bachelor's Thesis, students will gain initial experience in the independent solution of a technical-scientific problem by applying the acquired specialist and social skills. A Bachelor's Thesis should take about half of a student's time during one semester, i.e., about 300-400 hours. The thesis includes an oral presentation and a written report, and it is graded.

Objective
see above
A 14 week long Bachelor's Thesis is the final part of the bachelor's program and shall therefore be taken during the semester in which the bachelor's diploma is acquired.

The minimum requirement for enrollment is the successful completion of:
- basic examination (examination blocks A+B)
- subjects of the second year (examination blocks 1-3)

Supervisor must be a professor at D-ITET or associated, see a link to the lists of those at https://ee.ethz.ch/studies/bachelor/third-year/bachelor-project.html

**227-1101-00L How to Write Scientific Texts**

<table>
<thead>
<tr>
<th>E-</th>
<th>0 credits</th>
<th>U. Koch</th>
</tr>
</thead>
</table>

**Abstract**
This four-hour course covers the basics of writing and presenting scientific work. The focus lies on the structure and the main elements of a scientific text. Formatting guidelines, citation rules, good practice of scientific writing and hints to convince the audience are part of the course.

**Objective**
- You can write scientific texts using the correct structure
- You can convincingly present scientific work
- You can differentiate the scientific style from novels and news
- You can adhere to citation rules and scientific integrity

**Content**
The block course covers the following topics:
- Structure of Scientific Texts
- Structure of Scientific Presentations
- Formatting of Scientific Elements (figures, equations, tables)
- Citation Rules and Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

**Literature**
Scientific Integrity, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

**Prerequisites / notice**
You should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
</tr>
</tbody>
</table>

**Electrical Engineering and Information Technology Bachelor - Key for Type**

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Educational Science

General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC". Please note that the course unit number will change as of HS24. This change has no influence on the course units and achievements completed so far and will be recognized for the respective degree.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern, M. Rau</td>
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<td></td>
<td>This lecture is only apt for students who intend to enrol in the</td>
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<td></td>
<td>programs &quot;Teaching Diploma&quot; or &quot;Teaching Certificate&quot;. It is about</td>
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<td></td>
<td>learning in childhood and adolescence.</td>
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<td>Objective</td>
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<td></td>
<td>Anyone wishing to be a successful teacher must first of all</td>
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<td>understand the learning process. Against this background, theories</td>
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<td>and findings on the way humans process information and on human</td>
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<td>behaviour are prepared in such a manner that they can be used for</td>
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<td>planning and conducting lessons. Students additionally gain an</td>
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<td>understanding of what is going on in learning and behaviour research</td>
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<td>so that teachers are in a position where they can further educate</td>
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<td>themselves in the field of research into teaching and learning.</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Thematische Schwerpunkte: Lernen als Verhaltensänderung und als</td>
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<tr>
<td></td>
<td>Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer</td>
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<td>Berücksichtigung der Verarbeitung symbolischer Information; Lernen als</td>
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<td>Wissenskonstruktion und Kompetenzerwerb unter besonderer</td>
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<td></td>
<td>Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und</td>
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<td></td>
<td>Erklärungen; Die Rolle von Emotion und Motivation beim Lernen;</td>
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<td>Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen:</td>
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<td>Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<td></td>
<td>Lernformen: Theorien und wissenschaftliche Konstrukte werden zusammen</td>
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<td></td>
<td>mit ausgewählten wissenschaftlichen Untersuchungen in Form einer</td>
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<td></td>
<td>Vorlesung präsentiert. Die Studierenden vertiefen nach jeder Stunde die</td>
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<td>Inhalte durch die Bearbeitung von Aufträgen in einem elektronischen</td>
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<td></td>
<td>Lerntagebuch. Über die Bedeutung des Gelernten für den Schulalltag soll</td>
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<td>reflektiert werden. Ausgewählte Tagebucheinträge werden zu Beginn jeder</td>
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<td>Vorlesung thematisiert.</td>
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<td>Lecture notes</td>
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<td>Folien werden zur Verfügung gestellt.</td>
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<tr>
<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>1) Marcus Hasselhorn &amp; Andreas Gold (2006). Pädagogische Psychologie:</td>
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<td>Erfolgreiches Lernen und Lehren. Stuttgart: Kohlhammer. 2) Jeanne Omrod</td>
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<td>Greutmuth, Saalbach, Stern (Hrsg.), (2020): Professionelles</td>
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<td></td>
<td>Handlungswissen für Lehrerinnen und Lehrer. Kohlhamn Verlag</td>
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<td></td>
<td>Prerequisites / notice</td>
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<td>This lecture is only apt for students who intend to enrol in the</td>
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<td></td>
<td>programs &quot;Lehrpliom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning</td>
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<td>in childhood and adolescence.</td>
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<td>871-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W DZ)</td>
<td>2</td>
<td>3S</td>
<td></td>
<td>S. Maurer, P. Caprez, I. Sargenti</td>
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<td></td>
<td>The successful participation in EW1 (&quot;Human Learning&quot;) and EW2</td>
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<td></td>
<td>(&quot;Designing Learning Environments for School&quot;) is not recommended, but</td>
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<td>a mandatory prerequisite.</td>
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<td>Abstract</td>
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<td></td>
<td>In this class, students will learn concepts and skills for coping</td>
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<td>with psychosocial demands of teaching</td>
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<td>Objective</td>
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<td></td>
<td>Students possess theoretical knowledge and practical competences to</td>
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<td>be able to cope with the psychosocial demands of teaching.</td>
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<td>(1) They know relevant rules of conversation and conflict management</td>
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<td>and are able to apply them in an appropriate way in the school</td>
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<td>context (e.g. in parental talks).</td>
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<td>(2) They know core aspects of classroom management and know how to</td>
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<td>apply it concretely (e.g. promoting a positive learning atmosphere,</td>
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<td>avoiding disciplinary difficulties) and they are aware of possible</td>
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<td>contacts (e.g. illegal or psychological services).</td>
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<tr>
<td>871-0242-05L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>2</td>
<td>2S</td>
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<td>R. Schumacher</td>
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<td>Enrolment only possible with matriculation in Teaching Diploma or</td>
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<td>Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td></td>
<td>This course unit can only be enrolled after successful participation</td>
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<td></td>
<td>in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>This seminar focuses on teaching units in chemistry, physics and</td>
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<td>mathematics that have been developed at the MINT Learning Center of</td>
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<td>the ETH Zurich. In the first meeting, the mission of the MINT Learning</td>
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<td>Center will be communicated. Furthermore, in groups of two, the</td>
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<td>students will intensively work on, refine and optimize a teaching</td>
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<td>unit following a goal set in advance.</td>
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<td>Objective</td>
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<td></td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td>- Get information about recent literature on learning and instruction</td>
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<td>Prerequisites / notice</td>
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<td></td>
<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und</td>
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<td></td>
<td>persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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<tr>
<td>871-0242-07L</td>
<td>Human Intelligence</td>
<td>1</td>
<td>1S</td>
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<td>E. Stern</td>
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<td>Enrolment only possible with matriculation in Teaching Diploma or</td>
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<td>This course unit can only be enrolled after successful participation</td>
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<td>Abstract</td>
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<td></td>
<td>The focus will be on the book &quot;Intelligenz: Große Unterschiede un und</td>
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<td>ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting</td>
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<td>is obligatory. It is required that all participants read the complete</td>
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<td>book. Furthermore, in two meetings of 90 minutes, concept papers</td>
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<td>developed in small groups (5 - 10 students) will be discussed.</td>
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<td>Objective</td>
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<tr>
<td></td>
<td>- Understanding of research methods used in the empirical human sciences</td>
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<td>- Getting to know intelligence tests</td>
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<td>- Understanding findings relevant for education</td>
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<tr>
<td>871-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>2</td>
<td>1S</td>
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<td>U. Markwalder</td>
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<td>Enrolment only possible with matriculation in Teaching Diploma*</td>
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<td>(TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).</td>
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Data: 02.07.2024 12:39    Autumn Semester 2024    Page 977 of 2667
Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar (ca. 16 h), 2) collaboration with elementary school teacher in a class (ca. 34 h, with approx. 50% spent in the elementary or middle school class and ca. 50% for preparation), and 3) final report (ca. 10 h). Registration implies participation in all 3 parts.

Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.). During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students' level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

Lecturers
- Q. Lohmeyer
- R. Büchi

Lecture notes
Lecture materials are provided via Moodle.

Prerequisite: Educational science course already completed or at the same time.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0857-00L</td>
<td>Subject Didactics I for D-MAVT and D-ITET</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>Q. Lohmeyer, R. Büchi</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Didactics I focuses on teaching techniques as building blocks of typical lessons. This is done on the basis of the findings of teaching and learning research and their implementation in practice. The aim is the planning and implementation of effective teaching sequences as well as their evaluation and reflection.</td>
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<td>Objective</td>
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<td>- The students can plan, conduct and critically reflect single lessons.</td>
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<td>- They orient themselves towards the academic goals and take into account existing knowledge, the professional environment and the ambitions of the students.</td>
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<td></td>
<td>- They can apply the basic teaching principles meaningfully in their subject and suitably structure the learning phases.</td>
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<td>- They can reduce and present complex technical content such that it is in a form suitable for the students to learn.</td>
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<td>- They have considered examples of the common conceptual errors encountered by students</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>- Planning a teaching unit</td>
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<td></td>
<td>- Opening a lecture</td>
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<td>- Direct Instruction</td>
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<td>- Embedded exercises</td>
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<td>- Learning objectives</td>
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<td>- Practicing teaching</td>
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<td></td>
<td>- Excursion Fachhochschule</td>
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</table>

|              | Lecture notes                                          | 10 h |
|              | Prerequisites / notice                                  |      |
|              | Prerequisite: Educational science course completed or at the same time. |      |

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0859-10L</td>
<td>Teaching Internship Including Examination Lessons</td>
<td>O</td>
<td>6</td>
<td>13P</td>
<td>R. Büchi</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.</td>
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<td>Objective</td>
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<td></td>
<td>- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.</td>
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<td>- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.</td>
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<td>- They learn the skills of the teaching trade.</td>
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<td>- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.</td>
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<td>- They learn to assess pupils' work.</td>
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<td>- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.</td>
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</tbody>
</table>

Important: You can only enroll in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Lecture notes

Dokument: schriftliche Vorbereitung für Prüfungslekktionen.

Literature

Wird von der Praktikumslehrperson bestimmt.

227-0854-00L  Mentored Work Subject Didactics Electrical Engineering and Information Technology

Prerequisites: successful completion of FD I and FD II

Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

Objective

The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content


Typisch soll die Arbeit 3 - 4 Unterrichts-Einheiten à 45 Minuten abdecken (bei Einzelarbeit), bei Arbeit zu zweit mindestens 6 solche Einheiten.


Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Lecture notes

Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.

Literature

K. Frey, Allgemeine Didaktik, FH-Skript bzw. Lehrbuch des Praktikumslehrers.

Prerequisites / notice

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Electrical Engineering and Information Technology TC - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>O Compulsory</th>
<th>E- Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+ Eligible for credits and recommended</td>
<td>Z Courses outside the curriculum</td>
<td></td>
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<tr>
<td>W Eligible for credits</td>
<td>Dr Suitable for doctorate</td>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>V lecture</th>
<th>P practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G lecture with exercise</td>
<td>A independent project</td>
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<tr>
<td>U exercise</td>
<td>D diploma thesis</td>
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<tr>
<td>S seminar</td>
<td>R revision course / private study</td>
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<tr>
<td>K colloquium</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 979 of 2667
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is

Type H.

Lecture notes will be distributed electronically at the beginning of the semester.

- Analytical Competencies
  - discrete-time linear systems and filters:
    - state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.
    - The second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.


The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the main building blocks of modern digital communication systems. The topics include:

1. Discrete-time linear systems and filters:
   - state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.
2. The second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.


The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol interference, detection theory, as well as the basics of forward error correction and information theory.

After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to:

- understand the fundamentals of digital communication systems
- explain the principles of modulation, demodulation, detection, and error correction
- analyze error rates of simple digital communication systems
- implement simple MATLAB simulations to calculate error rates

The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the main building blocks of modern digital communication systems. The topics include:

- essential components of digital communication systems
- analog and digital modulation
- baseband and passband representation; up- and down-conversion
- communication channels as LTI systems
- discretizing communication systems; sampling and quantization
- noise, signal-to-noise ratio (SNR), and interference
- detection theory and error rates
- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to:

- understand the fundamentals of digital communication systems
- explain the principles of modulation, demodulation, detection, and error correction
- analyze error rates of simple digital communication systems
- implement simple MATLAB simulations to calculate error rates

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.

Content

- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
- Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes

* Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Literature

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

Prerequisites / notice


227-0417-00L Information Theory I W 6 credits 4G A. Lapidoth

Abstract

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equipartition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective

The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Communication", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

Number Title Type ECTS Hours Lecturers
227-0102-00L Discrete Event Systems W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer

Abstract

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.

Objective

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by exploring the limits of what is computable and what is not. In doing so, we will consider three distinct models of computation which are often used to model discrete event systems: finite automata, push-down automata and Turing machines (ranked in terms of expressiveness power). In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply continuous time markov chains and queueing theory for an understanding of the typical behavior of a system. Then we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queueing. In the last part of the course we introduce methods that allow to formally verify certain properties of Finite Automata and Petri Nets. These are some typical analysis questions we will look at: Do two given systems behave the same? Does a given system behave as intended? Does the system eventually enter a dangerous state?

Content

1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets

Lecture notes

Available at https://disco.ethz.ch/courses/des/
**Literature**

- [bertsekas] Data Networks
  Dimitri Bertsekas, Robert Gallager

- [borodin] Online Computation and Competitive Analysis
  Allan Borodin, Ran El-Yaniv.
  Cambridge University Press, 1998

- [burch] Symbolic Model Checking
  Inf. Comput. 98, 2 (June 1992), pp. 142-170

- [boudec] Network Calculus
  J.-Y. Le Boudec, P. Thiran
  Springer, 2001

- [cassandras] Introduction to Discrete Event Systems
  Christos Cassandras, Stéphane Lafortune.

- [fiat] Online Algorithms: The State of the Art
  A. Fiat and G. Woeginger

  D. Hochbaum

- [murata] Petri Nets: Properties, Analysis and Applications
  Tadao Murata

- [schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitsrechnung und Statistik)
  T. Schickinger, A. Steger
  Springer, Berlin, 2001

- [sipser] Introduction to the Theory of Computation
  Michael Sipser.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Problem-solving

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Problem-solving

- **Social Competencies**
  - Communication

- **Personal Competencies**
  - Adaptability and Flexibility
  - Critical Thinking

**227-0103-00L Control Systems**

**Abstract**
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Objective**
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Content**

**Literature**

**Prerequisites / notice**
Prerequisites: Signal and Systems Theory II.
MATLAB is used for system analysis and simulation.

**227-0116-00L VLSI 1: HDL Based Design for FPGAs**

**Abstract**
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

**Objective**
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level nelligists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

**Literature**
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
  - Register Transfer Level (RTL) synthesis and its limitations.
  - Building blocks of digital VLSI circuits.
  - Functional verification techniques and their limitations.
  - Modular and largely reusable testbenches.
  - Assertion-based verification.
  - Synchronous versus asynchronous circuits.
  - The case for synchronous circuits.
  - Periodic events and the Anceau diagram.
  - Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

### Literature
- **Textbook and all further documents in English.**
- N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

### Prerequisites
- **Basics of digital circuits.**
- **Subject-specific Competencies**
  - Analog Integrated Circuits
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Problem-solving

### Content
- **Method-specific Competencies**
  - Analog Integrated Circuits
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Problem-solving

### Notice
- In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

### Further details:
- https://iis-students.ee.ethz.ch/lectures/vlsi-i/
1. Universal approximation with single- and multi-layer networks

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

Content

- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
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- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes are handed out.

Literature


Prerequisites / notice

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is assessed. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmision Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

Compliance This lecture very well in that respect.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements This lecture very well in that respect.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/ the example of Cm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves. At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analogue continuous-time, analogue discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Cm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

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At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analogue continuous-time, analogue discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Cm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.
Content
Fundamentals of acoustics, calculation of sound fields, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, noise and noise control.

Lecture notes
yes

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies fostered

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Social Competencies
- Communication assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed
- Self-direction and Self-management fostered


decoupled from acoustic events such as the noise of industrial processes, machine sounds, and vehicular traffic, which is a major source of noise pollution. The impact of noise on human health and the environment is a crucial issue, as it can lead to hearing loss, stress, and decreased productivity. The study of noise control involves understanding the sources of noise, the mechanisms of sound transmission, and the techniques for reducing or managing noise levels. This includes the design and application of sound-absorbing materials, the use of barriers and screens, and the implementation of effective noise control strategies in buildings and urban planning. The course will cover fundamental concepts of acoustics, including sound propagation, absorption, and transmission, as well as the measurement and analysis of acoustical events.

Abstract
Maxwell’s equations are reinterpreted in the framework of Einstein’s special relativity theory using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

Objective
D-ITET is the depository of the Maxwell’s equations, which are dissected from all perspectives in the courses Physics I, Electromagnetic Fields and Waves, and Advanced Electromagnetic Waves.

Content
- Galileo-Newton, the Ether, Michelson-Morley’s Experiment
- Lorentz Transformations
- 4-Vectors in Minkowski’s Spacetime: Tensor Formalism
- The Lagrangian, the Principle of Stationary Action for Particles and Fields, Noether's Theorem
- Maxwell’s Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac's Effect
- GPS

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Literature
- (Special Relativity) L. Susskind and A. Friedman, “Special Relativity and Classical Field Theory: The Theoretical Minimum”, 2019, Hachette Book Group USA

Supplementary material will be uploaded in Moodle.

Prerequisites / notice
Furthermore, a solid base of Analysis I & II as well as of Linear Algebra is really helpful.
Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### 401-3055-64L Algebraic Methods in Combinatorics

**Abstract**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

**Content**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):
- Basic dimension arguments
- Spaces of polynomials and tensor product methods
- Eigenvalues of graphs and their application
- The Combinatorial Nullstellensatz and the Chevalley-Warning theorem

Applications such as:
- Solution of Kakeya problem in finite fields
- Counterexample to Borsuk's conjecture
- Chromatic number of the unit distance graph of Euclidean space
- Explicit constructions of Ramsey graphs and many others.

**Lecture notes**
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

**Prerequisites / notice**
Students are expected to have a mathematical background and should be able to write rigorous proofs.

### Track: Computers and Networks

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Computers and Networks", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

### Core Courses

These core courses are particularly recommended for the field of "Computers and Networks". You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

### Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>L. Josipovic, L. Vanbever, R. Wattenhofer</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.
Objective

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by exploring the limits of what is computable and what is not. In doing so, we will consider three distinct models of computation which are often used to model discrete event systems: finite automata, push-down automata and Turing machines (ranked in terms of expressiveness power). In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply continuous time markov chains and queueing theory for an understanding of the typical behavior of a system. Then we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queueing. In the last part of the course we introduce methods that allow to formally verify certain properties of Finite Automata and Petri Nets. These are some typical analysis questions we will look at: Do two given systems behave the same? Does a given system behave as intended? Does the system eventually enter a dangerous state?

Content

1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets

Lecture notes

Available at https://disco.ethz.ch/courses/des/

[bertsekas] Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin] Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv.
Cambridge University Press, 1998

[burch] Symbolic Model Checking
Inf. Comput. 98, 2 (June 1992), pp. 142-170

[boudec] Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras] Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune.

[fiat] Online Algorithms: The State of the Art
A. Fiat and G. Woeginger

D. Hochbaum

[murata] Petri Nets: Properties, Analysis and Applications
Tadato Murata

[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser] Introduction to the Theory of Computation
Michael Sipser.

Competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Problem-solving

Social Competencies

Communication
Adaptability and Flexibility

Personal Competencies

Creative Thinking
Critical Thinking

227-0121-00L Communication Systems W 6 credits 4G C. Studer, S. M. Moser

Abstract

The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol interference, detection theory, as well as the basics of forward error correction and information theory.

Objective

After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to:
- understand the fundamentals of digital communication systems
- explain the principles of modulation, demodulation, detection, and error correction
- analyze error rates of simple digital communication systems
- implement simple MATLAB simulations to calculate error rates
The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the main building blocks of modern digital communication systems. The topics include:
- essential components of digital communication systems
- analog and digital modulation
- baseband and passband representation; up- and down-conversion
- communication channels as LTI systems
- discrete-time communication systems; sampling and quantization
- noise, signal-to-noise ratio (SNR), and interference
- detection theory and error rates
- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

- building blocks of modern communication systems

An embedded system is a combination of hardware and software, either fixed in function or programmable, that is designed for a specific application or for a specific task within a larger system. They are part of industrial machines such as agricultural and manufacturing equipment, automotive systems, medical equipment, household appliances, sensor networks, and the Internet of Things.

The course focuses on the design of embedded systems using formal models and methods.

Using formal models and methods for designing and optimizing embedded systems.

Gaining experience with practical applications of the C programming language, embedded real-time operating systems, and debug functionalities of the associated design environment to design, implement, and verify embedded firmware.

Through project-based activities, students will gain substantial experience in applying the C programming language in the context of embedded systems. Projects will involve developing and implementing firmware, utilizing embedded real-time operating systems, and exploring the debugging functionalities within design environments. This hands-on approach aims to bridge the gap between theoretical knowledge and practical application, allowing students to experience the full lifecycle of embedded system development from design to implementation and verification.

Project-based activities will involve developing and implementing firmware, utilizing embedded real-time operating systems, and exploring the debugging functionalities within design environments. This hands-on approach aims to bridge the gap between theoretical knowledge and practical application, allowing students to experience the full lifecycle of embedded system development from design to implementation and verification.
In 2023, the course will cover advanced topics in communication networks such as:

- Adaptability and Flexibility
- Communication
- Analytical Competencies

The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments.

By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:

- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Experience with Linux, low-level systems programming and computer architecture.

See https://safari.ethz.ch/architecture for past examples.

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See https://safari.ethz.ch/architecture for past examples.
Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies

- Cooperation and Teamwork: fostered

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-direction and Self-management: fostered

252-1414-00L System Security W 7 credits 2V+2U+2A S. Capkun, S. Shinde

Abstract

The first part of the course covers general security concepts and hardware-based support for security.

In the second part, the focus is on system design and methodologies for building secure systems.

Objective

In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content

The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: fostered

Social Competencies

- Communication: fostered

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered

263-4640-00L Network Security W 8 credits 2V+2U+3A P. De Vaere, S. Frei, K. Paterson, A. Perrig

Abstract

Some of today’s most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems.

This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective

- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content

The course will cover topics spanning four broad themes with a focus on the first two themes:

1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.
Subject-specific Competencies

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of...

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Computers and Networks", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.</td>
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<tr>
<td>Objective</td>
<td>The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust &quot;inversion&quot; of a linear filter.</td>
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<tr>
<td>Content</td>
<td>1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion. 2. The discrete Fourier transform and its use for digital filtering. 3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.</td>
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<tr>
<td>Lecture notes</td>
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<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Signal and Systems Theory II. MATLAB is used for system analysis and simulation.</td>
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<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>F. K. Gürkaynak</td>
</tr>
<tr>
<td>Abstract</td>
<td>This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.</td>
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<tr>
<td>Objective</td>
<td>Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.</td>
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This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.

SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Literature

Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<th>Literature</th>
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<tbody>
<tr>
<td>227-0555-00L</td>
<td>Distributed Systems</td>
<td>4</td>
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</table>

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We discuss the following concepts related to fault-tolerant distributed systems: client-server, serialization, two-phase protocols, three-phase protocols, Paxos, two generals problem, crash failures, impossibility of consensus, Byzantine failures, agreement, termination, validity, Byzantine agreement, king algorithm, asynchronous Byzantine agreement, authentication, signatures, reliable and atomic broadcast, eventual consistency, blockchain, cryptocurrencies such as bitcoin and Ethereum, proof-of-work, proof-of-liquid; smart contracts, quantum systems, fault-tolerant protocols such as pChain or pBFT, distributed storage, distributed hash tables, physical and logical clocks, causality, selfishness, game theoretic models, mechanism design.

The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous discussion, and create a synthesis report at the end of the course.

This course is for those interested in computer architecture. Registered students are expected to attend every lecture, participate in the discussion, and create a synthesis report at the end of the course.

Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

See https://safari.ethz.ch/architecture_seminar for past examples.

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

In this course, we will cover fundamental and cutting-edge research papers in computer architecture. The course will consist of multiple components that are aimed at improving students' technical skills in computer architecture, critical thinking and analysis on computer architecture concepts, as well as technical presentation of concepts and papers in both spoken and written forms.

The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous presentation and discussion of selected papers during lectures and a written report delivered by each student at the end of the semester. This course is for those interested in computer architecture. Registered students are expected to attend every lecture, participate in the discussion, and create a synthesis report at the end of the course.

This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.
Objective

Familiarize students with main architectural principles and concepts of embedded control systems.

Content

An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

Lecture notes

Lecture notes, lab instructions, supplemental material

Prerequisites / notice

Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website

http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

252-1411-00L Security of Wireless Networks  W  6 credits  2V+1U+2A  S. Capkun, K. Kostiainen

Abstract

This course discusses physical layer aspects of wireless communication and a wide range of security-related topics in the domain of wireless technologies. It mainly targets computer science students. Though useful, a background in signal processing or physical layer concepts is not required. A basic understanding of security (e.g. as taught in 252-0211.00L Information Security) is recommended.

Objective

After this course, students should be able to describe and classify security goals of and attacks on various wireless networks and technologies, with an emphasis on physical layer aspects.

Competencies

- Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)

401-3055-64L Algebraic Methods in Combinatorics  W  5 credits  2V+1U  not available

Abstract

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments
- Spaces of polynomials and tensor product methods
- Eigenvalues of graphs and their application
- Combinatorial Nullstellensatz and the Chevalley-Warning theorem
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at

https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Track: Electronics and Photonics

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Electronics and Photonics", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

Core Courses

These core courses are particularly recommended for the field of "Electronics and Photonics". You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

Foundation Core Courses

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Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0110-00L</td>
<td>Electromagnetic Waves: Materials, Effects, and Antennas</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>F. K. Gürkaynak, N. Yazdani</td>
</tr>
</tbody>
</table>

Abstract
This course provides profound knowledge about electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.

Objective
You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions.

You know how waves interact with matter and about nonlinear, scattering and resonant effects.

You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.

Content
The lecture covers the following topics:
- Generic time-harmonic electromagnetic fields
- Fundamental solutions of the wave equation
- Wave propagation in various types of materials
- Interaction of waves with matter
- Nonlinear effects
- Resonant effects
- Applications like scattering, waveguiding, radiation
- Radio frequency and optical antennas

Lecture notes
Lecture notes and slides will be handed out during the lectures.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication

Personal Competencies
- Critical Thinking

227-0116-00L | VLSI 1: HDL Based Design for FPGAs | W | 6 credits | 5G | F. K. Gürkaynak |

Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modelling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGA targets. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Lecture notes
Lecture notes and all further documents in English.

Literature

Prerequisites / notice
Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

Further details:
https://lis-students.ee.ethz.ch/lectures/vlsi-i/

227-0145-00L | Solid State Electronics and Optics | W | 6 credits | 4G | N. Yazdani, V. Wood |

Abstract
"Solid State Electronics" is an introductory condensed matter physics course covering crystal structure, electron models, classification of metals, semiconductors, and insulators, band structure engineering, thermal and electronic transport in solids, magnetoresistance, and optical properties of solids.

Objective
Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.

Prerequisites / notice
Recommended background:
Undergraduate physics, mathematics, semiconductor devices

227-0166-00L | Analog Integrated Circuits | W | 6 credits | 4G | T. Jang |

Abstract
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.
**Objective**
Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

**Content**
The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesis; switched capacitor circuits.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

**Lecture notes**
Handouts of presented slides. No script but an accompanying textbook is recommended.

**Literature**

#### Advanced Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0146-00L</td>
<td>Data Conversion System Design</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>T. Burger, G. Cervelli, R. Reutenmann</td>
</tr>
</tbody>
</table>

**Abstract**
This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.

**Objective**
Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. Students will learn the underlying principles of data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or algorithmic conversion are explained based on their operation principle accompanied with the appropriate mathematical calculations, including effects of non-idealities in some cases. After successful completion of the course students should understand the concept of an ideal A/D, know all major converter architectures, their principle of operation and what governs their performance.

**Content**
- Introduction: examples of data conversion architectures; information representation; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy.
- Dual-slope & successive approximation register (SAR) converters: dual slope principle & converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented capacitors.
- Algorithmic & pipelined A/D converters: algorithmic conversion principle; sample & hold stage; pipelined converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.
- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.
- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkle correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters; cascaded folding and interpolation.
- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.
- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-order delta-sigma modulation, circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.

**Lecture notes**
Slides are available online under https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/

**Literature**
- R. Reutenmann et al., CMOS Data Converters for Communications, Springer, 2010

**Prerequisites / notice**
It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
  - Analytical Competencies: fostered

**Objective**
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

**Content**
- * Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
  - * Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
  - * Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
  - * Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

**Lecture notes**
Lecture notes are handed out.

**Literature**
Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

**Prerequisites / notice**
C. Studer assessed, S. M. Moser

The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and at the end of this course, you will

2V+3U

This course focuses on the advanced concepts and designs of wireless circuits and systems. The first half introduces key building blocks

Type

M. Frimmer

Communication Systems, O. Castañeda Fernández

4G

2V+2U

Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is a flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy. Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

- Electromagnetic fields and waves (or equivalent)
- Physics I-II

227-0147-10L

VLSI 3: Full-Custom Digital Circuit Design

W

6 credits

2V+3U

C. Studer, O. Castañeda Fernández

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

At the end of this course, you will

• understand the design of the main building blocks of state-of-the-art digital integrated circuits
• be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
• be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
• understand the performance trade-offs between delay, area, and power consumption

The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

• Nanometer MOSFETs
• Static and dynamic behavior of complementary MOS (CMOS) inverters
• CMOS gate design, sizing, and timing
• Full-custom standard-cell design
• Wire models and parasitics
• Latch and flip-flop circuits
• Gate-level timing analysis and optimization
• Static and dynamic power consumption; low-power techniques
• Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
• Arithmetic and logic circuits
• Fixed-point and floating-point arithmetic
• Synchronous and asynchronous design principles
• Memory circuits (ROM, SRAM, and DRAM)
• In- and near-memory processing architectures
• Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

227-0663-00L

Nano-Optics

W

6 credits

2V+2U

M. Frimmer

Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is a flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

- Electromagnetic fields and waves (or equivalent)
- Physics I-II

227-0111-10L

Communication Electronics II

W

6 credits

2V+2U

H. Wang

This course focuses on the advanced concepts and designs of wireless circuits and systems. The first half introduces key building blocks and popular topologies of low noise amplifiers, power amplifiers, T/R switches, phase shifters, variable gain amplifiers, and combiners/splitters. The second half will cover advanced phased array systems for 5G/6G, satellite communication (SATCOM), and radars.

227-0121-00L

Communication Systems

W

6 credits

4G

C. Studer, S. M. Moser

The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol interference, detection theory, as well as the basics of forward error correction and information theory.

After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to:

- understand the fundamentals of digital communication systems
- explain the principles of modulation, demodulation, detection, and error correction
- analyze error rates of simple digital communication systems
- implement simple MATLAB simulations to calculate error rates

These specialisation courses are particularly recommended for the area of "Electronics and Photonics", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.
The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the main building blocks of modern digital communication systems. The topics include:
- essential components of digital communication systems
- analog and digital modulation
- baseband and passband representation; up- and down-conversion
- communication channels as LTI systems
- discretizing communication systems; sampling and quantization
- noise, signal-to-noise ratio (SNR), and interference
- detection theory and error rates
- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.

Lecture notes
Lecture notes will be distributed electronically at the beginning of the semester.

Literature

A. Schenk
assessed

T. Jang
Machine Learning on Microcontrollers

Objective
Learn to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

Content
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayesian Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low-power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Prerequisites
C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable

Lecture notes
Script and exercise sheets. Books will be suggested during the course.

227-0155-00L
Machine Learning on Microcontrollers

Registration in this class requires the permission of the instructors. Preference is given to students in the MSc EEIT.

Abstract
Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly "smart". This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the "internet-of-things", using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V)

Objective
Learn to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

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- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low-power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

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Prerequisites
C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable

Lecture notes
Script and exercise sheets. Books will be suggested during the course.

227-0157-00L
Semiconductor Devices: Physical Bases and Simulation

Abstract
The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

Objective
The course aims at the understanding of the principle physics of modern semiconductor devices. of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

Content
The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions. The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

Lecture notes
The script (in book style) can be downloaded from: https://lis-students.ee.ethz.ch/lectures/

Literature
The script (in book style) is sufficient. Further reading will be recommended in the lecture.

Prerequisites

227-0166-00L
Analog Integrated Circuits

Abstract
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

Objective
Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems. The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

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Lecture notes
The script (in book style) can be downloaded from: https://lis-students.ee.ethz.ch/lectures/

Literature
The script (in book style) is sufficient. Further reading will be recommended in the lecture.

Prerequisites

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1000 of 2667
Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes

Handsouts of presented slides. No script but an accompanying textbook is recommended.

Literature


227-0377-10L Physics of Failure and Reliability of Electronic

Devices and Systems W 3 credits 2V I. Shorubalko, M. Held

Abstract

Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective

Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content

Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Lecture notes

Comprehensive copy of transparencies

Literature


227-0443-00L Space Communications W 4 credits 2V+2U J. Smajic, M. Burla, J. Leuthold, R. Muff

Abstract

The course has the following main goals: (a) to give a comprehensive overview of challenges on communication equipment imposed by space flight missions, (b) to present the theoretical fundamentals and existing practical solutions of communication technology for space missions, and (c) to review existing and future communication technologies for inter-satellite links, inter-spacecraft links, as well as satellite-terrestrial uplinks.

Objective

After completing this course, a student will understand the challenges of space flight imposed on communication components and systems, the available existing solutions of those problems, the main components of communications systems suitable for a spacecraft, and future technologies capable of enabling ultra-fast RF/mm-Wave, THz, and Laser communication links.

Content

- Space missions: scenarios and challenges on flight equipment
- Space communications: architectures, assets, payloads, link budgets, and use cases.
- Electromagnetic waves: radiation, operating principles of antennas, antenna types, and antenna parameters.
- RF electronics and antenna arrays architecture for SATCOM: low-noise amplifiers, beam forming, spatial filtering, and design examples.
- Laser communication links for free-space communication, architectures and implementation
- Microwave photonics for space applications: analog photonic links, optical generation and distribution of RF signals, and advanced RF filtering using photonic techniques.
- Communication channels: channel modeling, incl. atmospheric effects, Doppler, synchronization tracking, beam forming, tracking and finding.
- Signal modulation: modulation formats, adaptive optics, phase noise, and quantum key distribution (QKD).
- Outlook for emerging use-cases (ranging, time-, nav- and position-transfer (PNT))

Lecture notes

Lecture notes, Matlab programs, exercises and their solutions will be handed out.

Literature


227-0468-00L Analog Signal Processing and Filtering W 6 credits 2V+2U H. Schmid

Abstract

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

Objective

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.

Content

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.
The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites / notice

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

Competencies

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227-0615-00L Simulation of Photovoltaic Devices - From Materials to W 3 credits 2G U. Aeberhard

Abstract

The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the macroscopic description of component materials to microscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules.

Objective

Get an overview of the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to analyze, optimize, and predict the performance of solar cells and modules.

Content

Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture).

Literature

- M. A. Green, „Solar cells: operating principles, technology, and system applications“, Prentice Hall, 1982.

Prerequisites / notice

Undergraduate physics (including basic quantum mechanics), mathematics, semiconductor devices, optics. Knowledge of some scripting language (e.g. python) is of advantage.

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The students will appreciate the potential of solar radiation and photovoltaics, will learn the physics and technology of various solar cells, and will get to know the design basics of PV modules and systems for different applications.

Lecture notes Lecture slides (PDF files in English) will be available on Moodle and lecture recordings will be available on the ETH video portal.

Prerequisites / notice Prerequisites: Basic knowledge of semiconductors.

Competencies Subject-specific Competencies
Modeling, Characterization and Reliability of Power
Semiconductors
Does not take place this semester.

227-0618-00L
Solar Cells
Physics, technology, characteristics and applications of photovoltaic solar cells and systems.

Objective The students will appreciate the potential of solar radiation and photovoltaics, will learn the physics and technology of various solar cells, and will get to know the design basics of PV modules and systems for different applications.

Content Introduction to photovoltaics and economic aspects, solar radiation, semiconductor physics and operation of solar cells, technology of wafer-based (Si, GaAs, multi-junction) and thin-film (CIGS, CdTe, perovskite) solar cells, emerging technologies, design of PV modules, systems and plants including system components such as inverters and controllers, and procedures with software demonstration, integration in buildings and other specific examples such as concentrated photovoltaics and power generation for space applications.

Lecture notes Lecture slides (PDF files in English) will be available on Moodle and lecture recordings will be available on the ETH video portal.

Prerequisites / notice Prerequisites: Basic knowledge of semiconductors.

Competencies Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed
assessed

227-0619-00L
Charge Transport in Energy Conversion and Storage
Devices
W 6 credits 2V+2U

Objective The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolysers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in electrical engineering, materials science, physics, and chemistry.

Content By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolysers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

Lecture notes Handouts to the lecture (approx. 250 pp.)

Literature Eiichi Ohno: “Introduction to Power Electronics”
B. Muri et al.: “Smart Power ICs”
B. J. Baliga: “Physics Modern Power Devices”
S. K. Ghani: “Semiconductor Power Devices”

227-0652-00L
Maxwell, Einstein, and the GPS
W 6 credits 2V+2U

Objective Maxwell’s equations are reinterpreted in the framework of Einstein’s special relativity theory using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

Content Only one aspect is left over: the fact that they are not invariant with respect to the classical Galilean transformation… On the contrary, Maxwell’s equations predict that the light speed is the same for every inertial frame of reference. In this course, we will deepen how Einstein solved this clash elaborating the theory of “special relativity”. Maxwell’s equations are thus naturally derived in a breath-taking fashion from the principle of stationary action within the Lagrangian formalism.

Prerequisites / notice

Competencies Subject-specific Competencies
Maxwell, Einstein, and the GPS
Concepts and Theories
assessed
Content

- Galileo-Newton, the Ether, Michelson-Morley's Experiment
- Lorentz Transformations
- 4-Vectors in Minkowski's Spacetime: Tensor Formalism
- The Lagrangian, the Principle of Stationary Action for Particles and Fields, Noether's Theorem
- Maxwell's Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac's Effect
- GPS

Lecture notes

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Literature

- (Special Relativity) L. Susskind and A. Friedman, "Special Relativity and Classical Field Theory: The Theoretical Minimum", 2019, Hachette Book Group USA

Supplementary material will be uploaded in Moodle.

Prerequisites / notice

Furthermore, a solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

227-0627-00L Applied Computer Architecture W 6 credits 4G A. Gunzinger

Abstract

This lecture gives an overview of the requirements and the architecture of parallel computer systems, performance, reliability and costs.

Objective

Understand the function, the design and the performance modeling of parallel computer systems.

Content

The lecture "Applied Computer Architecture" gives technical and corporate insights in innovative Computer Systems/Architectures (CPU, GPU, FPGA, dedicated processors) and their real implementations and applications. Often the designs have to deal with technical limits.
Which computer architecture allows the control of the over 1000 magnets at the Swiss Light Source (SLS) at the PSI?
Which architecture is behind the alarm center of the Swiss Railway (SBB)?
Which computer architectures are applied for driver assistance systems?
How can data streams of about 30 TB/s, produced by a protone accelerator, be processed in real time?
Can the weather forecast also be processed with GPUs?
How could a fast trading system be set up for the stock exchange?

Lecture notes

Script and exercises sheets.

Prerequisites / notice

Prerequisites:
Basics of computer architecture.
The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of noise in signal processing and its implications for data transmission and reception.

In the "Fachseminar IIS" the students learn to communicate topics, ideas or problems of scientific research by listening to more experienced authors and by presenting scientific work in a conference-like situation for a specific audience. Attendees have the possibility to become acquainted with a current topic by a literature study, and to present the results thereof in a 20 minutes talk in English. The participation at the seminar gives also an overview on current problems in modern nano- and opto-electronics.

The seminar aims at instructing graduate and PhD students in the basics of presentation techniques, i.e. "how to give a professional talk". The students learn how to find the right literature for a certain topic quickly, as well as how to prepare a talk for a scientific conference, i.e. presentation techniques. The students learn how to read the right literature for a certain topic quickly, as well as how to prepare a talk for a scientific conference, i.e. presentation techniques.

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Carbon-based Nanoelectronics

This course explores the exciting realm of carbon-based nanoelectronics, where the remarkable quantum properties of materials like graphene, carbon nanotubes, graphene nanoribbons, and single molecules are used for building electronic devices. The objective of this course is to understand how the electronic properties of carbon-based materials can be exploited for fabricating quantum devices. We will delve into both the theoretical and experimental aspects, discussing how these materials’ unique properties can be translated into device functionality.

On the theoretical side, we will cover how the chemical structure of the material and its dimensionality, ranging from 0D to 2D, affects the electronic properties. We will also discuss how charge carriers flow through the devices and what charge transport mechanisms are at play.

On the experimental side, we will cover how such devices are fabricated, including how the materials are synthesized. We will also discuss how to characterize the devices and assess their performance.

For each material, we will discuss:
- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

The course also includes a presentation by each student in which a related scientific publication is discussed. This presentation is compulsory and accounts for 30% of the grade.

Lecture notes: Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

Prerequisites / notice: A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking

Literature


Content

The course will cover the following carbon-based materials:
- Single-molecule
- Graphene (single layer, bilayer, twisted bilayer)
- Graphene nanoribbons
- Carbon nanotubes

For each material, we will discuss:
- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

Lecture notes: Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

Prerequisites / notice: A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies

Social Competencies
- Communication

Personal Competencies
- Creative Thinking

Literature


Content

The course will cover the following carbon-based materials:
- Single-molecule
- Graphene (single layer, bilayer, twisted bilayer)
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For each material, we will discuss:
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Lecture notes: Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

Prerequisites / notice: A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies

Social Competencies
- Communication

Personal Competencies
- Critical Thinking
This course covers analog circuits with a strong emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding the characteristics of neuromorphic circuit elements.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physical paradigms and devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning, and memory are implemented in the individual computational local within the individual computational nodes and are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and silicon cochleas for machine vision and audition, and real-time emulation of networks of biological neurons, and the development of artificial robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

**227-2037-00L**
**Physical Modelling and Simulation**

**Objective**
Basic knowledge of the fundamental equations and effects of electromagnetic, mechanical, and heat transfer. Understanding of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

**Content**
The course begins with an introduction to the fundamental equations and effects of electromagnetic, mechanical, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Method (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use their own simulation programs or choose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

**227-2211-00L**
**Seminar in Computer Architecture**

**Objective**
The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. Students will complete a number of practical design tasks to simulate CPU or memory subsystems, investigate various architectural design choices, and understand the underlying fundamental concepts and paper topics. The main goal is to write a comprehensive technical report that contributes to the class discussion. The course will cover the following topics:

- **Introduction to computer architecture**
- **Basic concepts of computer architecture**
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- **Basic concepts of computer architecture**

**Content**
The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. Students will complete a number of practical design tasks to simulate CPU or memory subsystems, investigate various architectural design choices, and understand the underlying fundamental concepts and paper topics. The main goal is to write a comprehensive technical report that contributes to the class discussion. The course will cover the following topics:

- **Introduction to computer architecture**
- **Basic concepts of computer architecture**
- **Basic concepts of computer architecture**
- **Basic concepts of computer architecture**
- **Basic concepts of computer architecture**

**Prerequisites / notice**
Students should (1) have done very well in Digital Design and Computer Architecture, Digital Circuits or a similar course and (2) show a genuine interest in Computer Architecture.
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course. The document provides sufficient information for the participants to successfully participate in the course.

Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Dual, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots. Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

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<tr>
<td>327-2210-00L</td>
<td>Thin Films Technology - From Fundamentals to Oxide Electronics</td>
<td>5</td>
<td>4G</td>
<td>M. Trassin, C. Schneider</td>
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</table>

Students who already took "327-2104-00L Inorganic Thin Films: Processing, Properties and Applications" AND "327-2132-00 Multifunctional Ferroic Materials: Growth and Characterisation" are not allowed to attend this course.

Abstract
Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal.

We will give an introduction to thin films deposition techniques and applications with a focus on the growth of multifunctional oxide thin films.

Objective
In this course students will obtain an overarching view on thin film deposition techniques with a focus on epitaxial deposition processes. The main learning objectives are:
- Identification of most relevant deposition technique for a given application.
- Understanding of growth mechanism and growth modes.
- Understanding strategies for engineering the functionalities of the films using the deposition process.
- Selection of the most appropriate characterization technique.
- Understanding device concepts and fundamental limits in the technology relevant ultra-thin limit.
- Assessing the relevance of scientific literature dealing with complex oxide thin films.

Content
A lab visit visit will be organized and students will participate to the design of thin films with atomic precision.

General description of the leading deposition routes including physical and chemical vapor deposition techniques (PVD and CVD) as well as so called "wet techniques" (e.g. spin coating and spray pyrolysis).

Growth modes and processes.

Part of the course discusses vacuum technologies.

Fundamental characterization techniques for application-relevant thin films as well as state of the art approaches for in situ and ex-situ determination of the structural, chemical and ferroic (ferromagnetic and ferroelectric) properties of films: (XRD for thin films, RHEED, EDX, scanning probe microscopy techniques, laser-optical characterization and many more)

Epitaxy for the advanced design and characterization of high quality thin films for energy efficient oxide electronics.

Types of ferroic order, multiferroics, multifunctional oxide materials, epitaxial strain related effects, oxide thin film based devices and examples.

Regular discussions on preselected scientific literature and mini-seminars will be organized.
Abstract
This course focuses on the sources of innovation (with a specific focus on digital technologies), the tools and techniques that organizations deploy to innovate routinely, and the strategic implications of technical change at different levels of analysis: individuals, firms and whole ecosystems.

Objective
This course intends to enable all students to:

- Acquire and understand the basic jargon, concepts and methods necessary to discuss, in a precise and concise manner, innovation processes and their outcomes at different levels of analysis.

- Analyze the differences between individual and organizational decision processes and their innovative outcomes.

Content
Organizations and people are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small. How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

Lecture notes
Slides will be available on the Moodle page

Literature
Readings will be available on the Moodle page

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics.

Competencies

<table>
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<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
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363-0389-00L Technology and Innovation Management

Abstract
This course focuses on the sources of innovation (with a specific focus on digital technologies), the tools and techniques that organizations deploy to innovate routinely, and the strategic implications of technical change at different levels of analysis: individuals, firms and whole ecosystems.

Objective
This course intends to enable all students to:

- Acquire and understand the basic jargon, concepts and methods necessary to discuss, in a precise and concise manner, innovation processes and their outcomes at different levels of analysis.

- Analyze the differences between individual and organizational decision processes and their innovative outcomes.

Content
Organizations and people are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small. How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

Lecture notes
Slides will be available on the Moodle page

Literature
Readings will be available on the Moodle page

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics.

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376-1176-00L Wearable and Mobile Technologies of the Future - Focus on Sports and Health

Abstract
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

Objective
Objective 1: Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2: Acquire skills to design novel non-invasive technologies for sport and health.
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem.
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course consists of two modules.

Module 1: Movement.
This module provides the scientific background needed to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies.

Module 2: Cardiac.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies and the latest data analysis techniques to monitor the cardiac cycle for assisting individuals in sport activities or monitoring their health conditions.

The students should be proficient in programming (any language).

- If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)
- If Biomedical Engineering Master’s: none
- If D-MAVT Master’s: none
- If D-HEST Master’s and PhD students:
  - If BSc in electrical/mechanical engineering or computer science: none
  - If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)

Prerequisites / notice

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Additional references distributed via moodle.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

Module 2: Cardiac.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies and the latest data analysis techniques to monitor the cardiac cycle for assisting individuals in sport activities or monitoring their health conditions.

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Module 1: Movement.

The Terahertz (THz) range (0.1 – 10 THz), lies between the infrared and microwave spectral regions and has become accessible in the past few years. This new capability has had great impact in scientific research, and has led to technological advances and to the development of a variety of applications and devices. This course provides an introduction to THz science, technology and applications.

The goal of this course is to enable students to determine whether a THz solution can be applied to a particular scientific or technological problem. Armed with the fundamentals of THz science and of current THz technologies, covered in this introductory course, students will be able to weigh the capabilities, advantages and limitations of THz tools to address topics ranging from phonons in solid state systems and molecular vibrations in solutions to medical imaging and wireless communications.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Additional references distributed via moodle.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

401-3055-64L Algebraic Methods in Combinatorics

Does not take place this semester.

Abstract

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem.
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Additional references distributed via moodle.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

402-0475-00L Terahertz Science and Applications

W 5 credits 2V+1U not available

Abstract

The Terahertz (THz) range (0.1 – 10 THz), lies between the infrared and microwave spectral regions and has become accessible in the past few years. This new capability has had great impact in scientific research, and has led to technological advances and to the development of a variety of applications and devices. This course provides an introduction to THz science, technology and applications.

Objective

The goal of this course is to enable students to determine whether a THz solution can be applied to a particular scientific or technological problem. Armed with the fundamentals of THz science and of current THz technologies, covered in this introductory course, students will be able to weigh the capabilities, advantages and limitations of THz tools to address topics ranging from phonons in solid state systems and molecular vibrations in solutions to medical imaging and wireless communications.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Additional references distributed via moodle.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

Track: Energy and Power Electronics
The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Energy and Power Electronics", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

>>> Core Courses

These core courses are particularly recommended for the field of "Energy and Power Electronics". You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

>>> Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

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<th>Number</th>
<th>Title</th>
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<td>Power Electronics</td>
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Abstract
Fields of application of power electronic converters, basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Content
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

Lecture notes
Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites / notice
Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
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- Negotiation
Personal Competencies
- Adaptable and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

227-0517-10L | Fundamentals of Electric Machines | W    | 6    | 4     | D. Bortis |

Abstract
This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

Objective
The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

Content
- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes
Lecture notes and associated exercises including correct answers.
### Advanced Core Courses

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<td>227-0117-00L</td>
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<td>C. Franck, U. Straumann</td>
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<td><strong>Abstract</strong></td>
<td>High electric fields are used in numerous technological and industrial applications such as electric power transmission and distribution, X-ray devices, DNA sequencers, flue gas cleaning, power electronics, lasers, particle accelerators, copying machines, .... High Voltage Engineering is the art of gaining technological control of high electrical field strengths and high voltages. The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice. - discussion of the field equations relevant for high voltage engineering, - analytical and numerical solutions/solving of these equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations - introduction to kinetic gas theory - mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems - methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations - application of the expertise on high voltage components - excursions to manufacturers of high voltage components</td>
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<td><strong>Prerequisites / notice</strong></td>
<td>Lecture notes</td>
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<td><strong>Objective</strong></td>
<td>The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice. - discussion of the field equations relevant for high voltage engineering, - analytical and numerical solutions/solving of these equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations - introduction to kinetic gas theory - mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems - methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations - application of the expertise on high voltage components - excursions to manufacturers of high voltage components</td>
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<td><strong>Number</strong></td>
<td>227-0247-00L</td>
<td>Power Electronic Systems I</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
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<td><strong>Abstract</strong></td>
<td>6 credits</td>
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<td><strong>Objective</strong></td>
<td>Basics of the switching behavior, gate drive and snubber circuits of power semiconductors are discussed. Soft-switching and resonant DC/DC converters are analyzed in detail and high frequency loss mechanisms of magnetic components are explained. Space vector modulation of three-phase inverters is introduced and the main power components are designed for typical industry applications. The operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.</td>
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<td><strong>Objective</strong></td>
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<td><strong>Number</strong></td>
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<td>Power System Analysis</td>
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<tr>
<td><strong>Abstract</strong></td>
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## Content

The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis and symmetrical components are discussed as well as power flow computation techniques for distribution grids and state estimation.

## Lecture Notes

Lecture notes

## Competencies

### Subject-specific Competencies

- **Concepts and Theories**
  - assessed

- **Techniques and Technologies**
  - assessed

### Method-specific Competencies

- **Analytical Competencies**
  - assessed

- **Media and Digital Technologies**
  - fostered

- **Problem-solving**
  - assessed

### Personal Competencies

- **Critical Thinking**
  - fostered

## Specialisation Courses

These specialisation courses are particularly recommended for the area of "Energy and Power Electronics", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H. A. Loeliger</td>
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<tr>
<td>Abstract</td>
<td>The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.</td>
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<tr>
<td>Objective</td>
<td>1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.</td>
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<tr>
<td>Content</td>
<td>2. The discrete Fourier transform and its use for digital filtering.</td>
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<td>3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.</td>
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<td>Lecture notes</td>
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<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
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<tr>
<td>Abstract</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Signal and Systems Theory II. MATLAB is used for system analysis and simulation.</td>
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<td>227-0121-00L</td>
<td>Communication Systems</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>C. Studer, S. M. Moser</td>
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<tr>
<td>Abstract</td>
<td>The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol interference, detection theory, as well as the basics of forward error correction and information theory.</td>
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<td>Objective</td>
<td>After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to: understand the fundamentals of digital communication systems; explain the principles of modulation, demodulation, detection, and error correction; analyze error rates of simple digital communication systems; implement simple MATLAB simulations to calculate error rates.</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1013 of 2667
The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the main building blocks of modern digital communication systems. The topics include:

- essential components of digital communication systems
- analog and digital modulation
- baseband and passband representation; up- and down-conversion
- communication channels as LTI systems
- discretizing communication systems; sampling and quantization
- noise, signal-to-noise ratio (SNR), and interference
- detection theory and error rates
- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.


**Lecture notes**

Lecture notes will be distributed electronically at the beginning of the semester.

**Literature**


**Competencies**

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Critical Thinking
- Integrity and Work Ethics

**227-0225-00L Linear System Theory**

**W 6 credits 4G** J. Lygeros, A. Tsiamis

**Abstract**

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of stability of linear control systems.

**Objective**

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

**Content**

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Lecture notes**

Lecture notes and associated exercises including correct answers available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Competencies**

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Critical Thinking
- Integrity and Work Ethics

**227-0517-10L Fundamentals of Electric Machines**

**W 6 credits 4G** D. Bortis

**Abstract**

This course introduces different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

**Objective**

The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

**Content**

- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

**Lecture notes**

Lecture notes and associated exercises including correct answers available on the course Moodle platform.

**Competencies**

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Personal Competencies
- Critical Thinking
- Integrity and Work Ethics

**227-0523-00L Railway Systems I**

**W 6 credits 4G** M. Meyer

**Abstract**

Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:

- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance
Objective

- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

Content

EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale

1. Einführung:
   1.1 Geschichte und Struktur des Bahnsystems
   1.2 Fahrdynamik

2. Vollbahnfahrzeuge:
   2.1 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
   2.2 Bremsen
   2.3 Traktionsantriebsysteme
   2.4 Hilfsbetriebe und Komfortanlagen
   2.5 Steuerung und Regelung

3. Infrastruktur:
   3.1 Fahrweg
   3.2 Bahnstromversorgung
   3.3 Sicherungsanlagen

4. Betrieb:
   4.1 Interoperabilität, Normen und Zulassung
   4.2 RAMS, LCC
   4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Geplante Exkursionen:
- Betriebszentrale SBB, Zürich Flughafen
- Reparatur und Unterhalt, SBB Zürich Altstetten
- Fahrzeugfertigung, Stadler Bussnang

Lecture notes

Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice

Dozent:
Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahnninfrastruktur.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed

Personal Competencies
Critical Thinking assessed

227-0536-00L Multiphysics Simulations for Power Systems

This course is defined so and planned to be an addition to the module "227-0537-00L Technology of Electric Power System Components". However, the students who are familiar with the fundamentals of electromagnetic fields could attend only this course without its 227-0537-00L-complement.

Abstract

The goals of this course are a) understanding the fundamentals of the electromagnetic, thermal, mechanical, and coupled field simulations and b) performing effective simulations of primary equipment of electric power systems. The course is understood complementary to 227-0537-00L "Technology of Electric Power System Components", but can also be taken separately.

Objective

The student should learn the fundamentals of the electromagnetic, thermal, mechanical, and coupled fields simulations necessary for modern product development and research based on virtual prototyping. She / he should also learn the theoretical background of the finite element method (FEM) and its application to low- and high-frequency electromagnetic field simulation problems. The practical exercises of the course should be done by using one of the commercially available field simulation software (Infolytica, ANSYS, and / or COMSOL).

After completing the course the student should be able to properly and efficiently use the software to simulate practical design problems and to understand and interpret the obtained results.

Content

1. Elektromagnetic Fields and Waves: Simulation Aspects (1 lecture, 2 hours)
   a. Short review of the governing equations
   b. Boundary conditions
   c. Initial conditions
   d. Linear and nonlinear material properties
   e. Coupled fields (electro-mechanical and electro-thermal coupling)

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
   a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
   b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
   c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
   d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
   a. Dielectric analysis of high-voltage equipment
   b. Nonlinear quasi-electrostatic analysis of surge arresters
   c. Eddy-currents analysis of power transformers
   d. Electromagnetic analysis of electric machines
   e. Very fast transients in gas insulated switchgears (GIS)
   f. Electromagnetic compatibility (EMC)

227-0567-00L Design of Power Electronic Systems

W 4 credits 2V+2U J. Smajic

Autumn Semester 2024
Abstract

Complete design process: from given specifications to a complete power electronic system; selection / design of suitable passive power components; static and dynamic properties of power semiconductors; optimized EMI filter design; heat sink optimization; additional circuitry, e.g. gate driver; system optimization.

Objective

Basic knowledge of design and optimization of a power electronic converter system; furthermore, lecture and exercises thoroughly discuss key subjects of power electronics that are important with respect to a practical realization, e.g. how to select or design suitable power components, to understand switching operations, calculation of high frequency losses, EMI filter design and realization, thermal considerations.

Content

Complete design process: from given specifications to a complete power electronic system. Selection and / or design of suitable passive power components: specific properties, parasitic components, tolerances, high frequency losses, thermal considerations, reliability. Static and dynamic characteristics of power semiconductors. Optimized design of the EMI filter. Thermal characterization of the converter, optimized heat sink design. Additional circuitry: gate driver, measurement, control. Converter start-up: typical sequence of events, circuitry required. Overall system optimization: identifying couplings between different components of the considered power electronic system, optimization targets and issues.

Lecture notes

Complementary exercises including correct answers.

Prequisites

Introductory course on power electronics.

Method-specific Competencies

Concepts and Theories: assessed
Techniques and Technologies: assessed
Analytical Competencies: assessed
Decision-making: assessed
Problem-solving: assessed

Personal Competencies

Adaptability and Flexibility: fostered
Critical Thinking: fostered

Subject-specific Competencies

Techniques and Technologies: assessed

Literature

227-0617-00L Solar Cells

W 4 credits 3G Y. Romanyuk, R. Carron

Objective

The students will appreciate the potential of solar radiation and photovoltaics, will learn the physics and technology of various solar cells, and will get to know the design basics of PV modules and system specifications, reliability, thermal considerations, and cost optimization.

Content

Introduction to photovoltaics and economic aspects, solar radiation, semiconductor physics and operation of solar cells, technology of wafer-based (Si, GaAs, multi-junction) and thin-film (CIGS, CdTe, perovskite) solar cells, emerging technologies, design of PV modules, systems and plants including system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples such as concentrated photovoltaics and power generation for space applications.

Lecture notes

Lecture slides (PDF files in English) will be available on Moodle and lecture recordings will be available on the ETH video portal.

Prequisites

Basic knowledge of semiconductors.

Subject-specific Competencies

Concepts and Theories: assessed
Techniques and Technologies: assessed

Literature

227-0618-00L Modeling, Characterization and Reliability of Power Semiconductors

W 6 credits 4G

Objective

The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems.

Content

This lecture consists of a theoretical part (50%) and of laboratory exercises and demonstrations (50%). The theoretical part covers the basic techniques and procedures for characterization, modeling and built-in reliability of modern power semiconductor devices with special attention to MOS and IGBT. The starting part on technology provides an overview on the main device families and includes a review of the most relevant application-oriented aspects of the device physics, thermal management, and packaging. The second section deals with practical techniques for characterization, modeling and built-in reliability of power semiconductors. The students will learn how to simulate the basic principles for electrical, thermal, and electro-thermal simulation of power semiconductors by Technology Computed Aided Design (TCAD) and compact modeling. Finally, procedures are methods to implement efficient built-in reliability programs targeted on power semiconductors. The students will learn failure physics, dedicated failure analysis techniques, accelerated testing, defect screening, and lifetime modeling.

During the laboratory activities, the students will get familiar with the experimental techniques presented in the lecture and demonstrate their knowledge and skills on the basis of realistic examples. Furthermore, schematic power devices will be simulated by the students using advanced TCAD tools and circuit simulators.

Lecture notes

Handouts to the lecture (approx. 250 pp.)

227-0619-00L Charge Transport in Energy Conversion and Storage

W 6 credits 2V+2U C. Battaglia, A. Senocerate Devices

Objective

The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolysers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in electrical engineering, materials science, physics, and chemistry.

Content

By the end of the course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolysers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

Literature

R. Huggins, Advanced Batteries, DOI:10.1007/9780387764245

Data: 02.07.2024 12:39
Autumn Semester 2024
**Prerequisites / notice**

Be motivated to change the world to renewable energies!

This course is taught simultaneously at ETH Zurich and EPFL. All lectures will be recorded by zoom and made available to the students. Lectures will be streamed live from ETH Zurich with four lectures taught onsite at EPFL Lausanne.

A visit to Empa's Energy Conversion and Storage Labs will be organized during the semester. Possibility to interact and meet your classmates from EPFL via online lecture platform and during two special lectures with guest lecturers from industry (one guest lecture by ABB at ETH Zurich, one guest lecture by Northvolt at EPFL). Travel expenses for students will be covered.

Elements of calculus will be reviewed during the lectures, where necessary, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite.

Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students.

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**Competencies**

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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<tr>
<td><strong>W 4 credits</strong></td>
<td><strong>3G 4G</strong></td>
<td><strong>A. Horch, L. Dominguez Palomeque</strong></td>
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<th>Techniques and Technologies</th>
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<tr>
<td><strong>227-0697-00L</strong></td>
<td><strong>Industrial Process Control</strong></td>
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</table>
### Track: Systems and Control

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of “Systems and Control”. See [https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html](https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html).

The individual study plan is subject to the tutor's approval.

#### Core Courses

These core courses are particularly recommended for the field of “Systems and Control”. You may choose core courses from other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

#### Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Döfler</td>
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<td>Abstract</td>
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<td></td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<td>Prerequisites / notice</td>
<td>MATLAB is used for system analysis and simulation.</td>
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#### Advanced Core Courses

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<th>Number</th>
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<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>J. Lygeros, A. Tsiamis</td>
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<td>Abstract</td>
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<td>The course is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.</td>
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<td>Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.</td>
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<td>- Proof techniques and practices.</td>
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<td>- Linear spaces, normed linear spaces and Hilbert spaces.</td>
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<td>- Ordinary differential equations, existence and uniqueness of solutions.</td>
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<td>- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.</td>
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<td>- Controllability and observability, duality. Time invariant systems treated as a special case.</td>
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<td>- Stability and stabilization, observers, state and output feedback, separation principle.</td>
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<td>Lecture notes</td>
<td>Available on the course Moodle platform.</td>
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<td>Prerequisites / notice</td>
<td>Sufficient mathematical maturity, in particular in linear algebra, analysis.</td>
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<td>Competencies</td>
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<td>Method-specific Competencies</td>
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<td>Integrity and Work Ethics</td>
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<tr>
<td>227-0697-00L</td>
<td>Industrial Process Control</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Horch, L. Dominguez Palomeque</td>
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<td>Abstract</td>
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<td></td>
<td>Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing. General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends.</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1018 of 2667
Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering. Differences and characteristics of discrete and process industries. Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry.

Lecture notes Literature Prerequisites / notice
Slides will be available as .PDF documents, see "Learning materials" (for registered students only)
References will be given at the end of individual lectures.
Exercises: Tuesdays after the lecture (applies not to all lectures)
Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.

Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

Abstract Objective Content
Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of representation methods
- Set-membership identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

Dynamic Programming and Optimal Control

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0371-00L</td>
<td>Advanced Model Predictive Control</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>M. Zeilinger, A. Carron, L. Hewing, J. Köhler</td>
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<tr>
<td>151-0563-01L</td>
<td>Dynamic Programming and Optimal Control</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>R. D’Andrea</td>
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</table>

These specialisation courses are particularly recommended for the area of "Systems and Control", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by exploring the limits of what is computable and what is not. In doing so, we will consider three distinct models of computation which are often used to model discrete event systems: finite automata, push-down automata and turing machines (ranked in terms of expressiveness power). In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply continuous time markov chains and queueing theory for an understanding of the typical behavior of a system. Then we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queueing. In the last part of the course we introduce methods that allow to formally verify certain properties of finite automata and Petri Nets. These are some typical analysis questions we will look at: Does two given systems behave the same? Does a given system behave as intended? Does the system eventually enter a dangerous state?

1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets
Lecture notes Available at https://disco.ethz.ch/courses/des/

[bertsekas] Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin] Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv.
Cambridge University Press, 1998

[burch] Symbolic Model Checking
Inf. Comput. 98, 2 (June 1992), pp. 142-170

[boudec] Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras] Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune.

[fiat] Online Algorithms: The State of the Art
A. Fiat and G. Woeginger

D. Hochbaum

[murata] Petri Nets: Properties, Analysis and Applications
Tadao Murata

[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser] Introduction to the Theory of Computation
Michael Sipser.

Competencies

<table>
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<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Problem-solving</th>
<th>Communication</th>
<th>Adaptability and Flexibility</th>
<th>Creative Thinking</th>
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227-0447-00L Image Analysis and Computer Vision

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Prerequisites:
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

227-0526-00L Power System Analysis

Abstract
The goal of this course is understanding the stationary dependencies in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

Objective
The goal of this course is understanding the stationary dependencies in electrical power systems and the application of analysis tools in normal but also in faulty state.

Content
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis and symmetrical components are discussed as well as power flow computation techniques for distribution grids and state estimation.

Lecture notes Lecture notes.
Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies fostered
Problem-solving assessed
Personal Competencies
Critical Thinking fostered

227-0689-00L System Identification W 4 credits 2V+1U R. Smith

Abstract
Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.

Objective
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.
Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.
Optimal experimental design, Cramer-Rao bounds, input signal design.
Parametric identification methods. On-line and batch approaches.
Closed-loop identification strategies. Trade-off between controller performance and information available for identification.

Literature
Additional papers will be available via the course Moodle.

Prerequisites / notice
Control systems (227-0216-00L) or equivalent.

151-0532-00L Nonlinear Dynamics and Chaos I W 4 credits 4G G. Haller

Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D’Andrea

Abstract
Introduction to Dynamic Programming and Optimal Control.

Objective
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Prerequisites / notice

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions W 3 credits 2V R. Riener, O. Lambercy

Abstract
Rehabilitation Eng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1021 of 2667
Content
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature
Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice
Target Group:
- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1022 of 2667
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks. The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

**Content**

Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

**Literature**

Information about relevant literature will be given in the lecture.

**Prerequisites / notice**

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

---

**Introduction to Mathematical Optimization**

**Abstract**

Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

**Objective**

The goal of the course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Prerequisites / notice**

Solid background in linear algebra.

---

**Linear & Combinatorial Optimization**

**Abstract**

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Prerequisites / notice**

Solid background in linear algebra.

---

**Computational Systems Biology**

**Abstract**

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

**Objective**

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

**Content**

Biological systems are highly complex. They consist of interconnected molecules, proteins, and cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

**Lecture notes**

http://www.csb.ethz.ch/education/lectures.html
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has fostered

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

Lecture notes will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Lectures will be made available via Moodle.

Students are expected to have a mathematical background and should be able to write rigorous proofs.
Core Courses

These core courses are particularly recommended for the field of “Signal Processing and Machine Learning”. You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.</td>
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<tr>
<td>Objective</td>
<td>The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust &quot;inversion&quot; of a linear filter.</td>
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</tr>
<tr>
<td>Content</td>
<td>1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.</td>
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<tr>
<td></td>
<td>2. The discrete Fourier transform and its use for digital filtering.</td>
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<td>3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture Notes</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students master the basic mathematical concepts and algorithms of estimation and machine learning.</td>
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<tr>
<td>Content</td>
<td>Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes will be handed out as the course progresses,</td>
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<tr>
<td>Prerequisites / notice</td>
<td>solid basics in linear algebra and probability theory</td>
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Advanced Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0423-00L</td>
<td>Neural Network Theory</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Bölcskei</td>
</tr>
<tr>
<td>Abstract</td>
<td>Does not take place this semester.</td>
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<tr>
<td>Objective</td>
<td>The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.</td>
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<tr>
<td>Content</td>
<td>After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.</td>
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<tr>
<td></td>
<td>1. Universal approximation with single- and multi-layer networks</td>
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<td></td>
<td>2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory</td>
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<tr>
<td></td>
<td>3. Fundamental limits of deep neural network learning</td>
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<td>4. Geometry of decision surfaces</td>
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<td></td>
<td>5. Separating capacity of nonlinear decision surfaces</td>
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<td></td>
<td>6. Vapnik-Chervonenkis (VC) dimension</td>
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<tr>
<td></td>
<td>7. VC dimension of neural networks</td>
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<tr>
<td>Lecture notes</td>
<td>Detailed lecture notes are available on the course web page</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.</td>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6</td>
<td>3V+1U</td>
<td>E. Konukoglu, E. Erdil, F. Yu</td>
</tr>
<tr>
<td>Objective</td>
<td>Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical and programming exercises.</td>
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</tbody>
</table>
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites:
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Principles of AI
https://las.inf.ethz.ch/teaching/pai-f18

Abstract
Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

Objective
Introduction to various mathematical aspects of Data Science.

Content
These topics lie in overlaps of Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Most lectures will feature Mathematical Open Problems. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

Lecture notes

Prerequisites / notice
The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies
Problem-solving assessed

Social Competencies
Communication
Cooperation and Teamwork
Sensitivity to Diversity

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Specialisation Courses
These specialisation courses are particularly recommended for the area of "Signal Processing and Machine Learning", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the MSc EEIT.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>F. K. Gürkaynak</td>
</tr>
</tbody>
</table>

Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conceptions to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.
Analytical Competencies

This course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the assessed H. Kaeslin: "Top-Down Digital VLSI Design, from Architectures to Gate-Level Circuits and FPGAs", Elsevier, 2014, ISBN 9780128007303.

After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding), Critical Thinking, Communication Systems, and Machine Learning on Microcontrollers are fostered. The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.

## Content

- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
  - Register Transfer Level (RTL) synthesis and its limitations.
  - Building blocks of digital VLSI circuits.
  - Functional verification techniques and their limitations.
  - Modular and largely reusable testbenches.
  - Assertion-based verification.
  - Synchronous versus asynchronous circuits.
  - The case for synchronous circuits.
  - Periodic events and the Anechoic diagram.
  - Case studies,ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

## Literature


## Prerequisites

Basics of digital circuits.

## Examination

In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

Further details: https://iis-students.ee.ethz.ch/lectures/vlsi-i/

## 227-0121-00L

**Communication Systems**

<table>
<thead>
<tr>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>C. Studer, S. M. Moser</th>
</tr>
</thead>
</table>

**Abstract**

The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol interference, detection theory, as well as the basics of forward error correction and information theory.

**Objective**

After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to:

- understand the fundamentals of digital communication systems
- explain the principles of modulation, demodulation, detection, and error correction
- analyze error rates of simple digital communication systems
- implement simple MATLAB simulations to calculate error rates

## Content

The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the main building blocks of modern digital communication systems. The topics include:

- essential components of digital communication systems
- analog and digital modulation
- baseband and passband representation; up- and down-conversion
- communication channels as LTI systems
- discretizing communication systems; sampling and quantization
- noise, signal-to-noise ratio (SNR), and interference
- detection theory and error rates
- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.

## Lecture notes

Lecture notes will be distributed electronically at the beginning of the semester.

## Literature


## Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Personal Competencies

- Critical Thinking
- Integrity and Work Ethics

## 227-0155-00L

**Machine Learning on Microcontrollers**

**Registration in this class requires the permission of the instructors. Preference is given to students in the MSC EEIT.**

**Abstract**

Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly "smart". This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the "internet-of-things", using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

**Objective**

Learn how to process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.
Content
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Lecture notes
Script and exercise sheets. Books will be suggested during the course.

Prerequisites / notice

227-0225-00L
Linear System Theory

Abstract
The course is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes
Available on the course Moodle platform.

Prerequisites / notice
Sufficient mathematical maturity, in particular in linear algebra, analysis.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
</tbody>
</table>

| Method-specific Competencies | Analytical Competencies | assessed |
|------------------------------| Problem-solving | assessed |

| Personal Competencies | Creative Thinking | fostered |
|-----------------------| Critical Thinking | fostered |
|                       | Integrity and Work Ethics | fostered |

227-0384-00L
Ultrasound Fundamentals and Applications in Biology and Medicine
Previously (up to spring 2020) offered as Ultrasound Fundamentals, Imaging, and Medical Applications

Abstract
Ultrasound waves are non-ionizing and thus provide a safe means to interrogate and treat biological tissues. Advantages such as real-time operation, low cost, and portability have led to ultrasound systems becoming standard tools in hospitals and research laboratories. Applications in biology and medicine include ultrasound and optoacoustic imaging, thermal therapy, or pulse stimulation.

Objective
The objective of the course is that students are able to understand how to use ultrasound in biology and medicine and generalize this knowledge to applications in other fields.

Content
The course will cover the basic physics of ultrasound (acoustic waves at frequencies higher than the audible range) in biological tissues as well as the instrumentation required to generate and detect these waves. Imaging methods will extensively be described in the course. Specifically, standard and ultra-fast ultrasound imaging approaches will be covered along with new optoacoustic and transmission ultrasound imaging methods. The course will also describe mathematical modelling approaches and numerical methods as well as signal and image processing tools applicable in ultrasound-based imaging. Other topics include ultrasound sensors, laser ultrasound, therapeutic effects, or biomedical applications and contrast agents. The course will conclude with current and future research directions in the field of ultrasound in biomedicine.

Lecture notes
The lecture slides will be made available to the students.

Prerequisites / notice
Basic knowledge in physics. Basic programming skills, preferably in Matlab.

227-0417-00L
Information Theory I

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective
The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content
The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature
T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

227-0421-00L
Learning in Deep Artificial and Biological Neuronal Networks

Abstract
Deep-Learning (DL) a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.
Objective

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Content

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes / notice

The lecture slides will be provided as a PDF after each lecture.

Prerequisites /

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:
1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

227-0477-00L

Acoustics I

Objective

Understanding of the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.

Content

Fundamentals of acoustics, calculation of sound fields, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures.

Lecture notes

yes

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management fostered

227-0560-00L

Computer Vision and Artificial Intelligence for Autonomous Cars ■

Up until FS2022 offered as Deep Learning for Autonomous Driving

Objective

This course introduces the core computer vision techniques and algorithms that autonomous cars use to perceive the semantics and geometry of their driving environment, localize themselves in it, and predict its dynamic evolution. Emphasis is placed on techniques tailored for real-world settings, such as multi-modal fusion, domain-adaptive and outlier-aware architectures, and multi-agent methods. Students will learn about the fundamentals of autonomous cars and of the computer vision models and methods these cars use to analyze their environment and navigate themselves in it. Students will be presented with state-of-the-art representations and algorithms for semantic, geometric and temporal visual reasoning in automated driving and will gain hands-on experience in developing computer vision algorithms and architectures for solving such tasks.

After completing this course, students will be able to:
1. understand the operating principles of visual sensors in autonomous cars
2. differentiate between the core architectural paradigms and components of modern visual perception models and describe their logic and the role of their parameters
3. systematically categorize the main visual tasks related to automated driving and understand the primary representations and algorithms which are used for solving them
4. critically analyze and evaluate current research in the area of computer vision for autonomous cars
5. practically reproduce state-of-the-art computer vision methods in automated driving
6. independently develop new models for visual perception
The content of the lectures consists in the following topics:

1. Fundamentals
   (a) Fundamentals of autonomous cars and their visual sensors
   (b) Fundamental computer vision architectures and algorithms for autonomous cars

2. Semantic perception
   (a) Semantic segmentation
   (b) Object detection
   (c) Instance segmentation and panoptic segmentation

3. Geometric perception and localization
   (a) Depth estimation
   (b) 3D reconstruction
   (c) Visual localization
   (d) Unimodal visual/lidar 3D object detection

4. Robust perception: multi-modal, multi-domain and multi-agent methods
   (a) Multi-modal 2D and 3D object detection
   (b) Visual grounding and verbo-visual fusion
   (c) Domain-adaptive and outlier-aware semantic perception
   (d) Vehicle-to-vehicle communication for perception

5. Temporal perception
   (a) Multiple object tracking
   (b) Motion prediction

The practical projects involve implementing complex computer vision architectures and algorithms and applying them to real-world, multi-modal driving datasets. In particular, students will develop models and algorithms for:

1. Semantic segmentation and depth estimation
2. Sensor calibration for multi-modal 3D driving datasets
3. 3D object detection using lidars

Lecture notes
Lecture slides are provided in PDF format.

Prerequisites / notice
Students are expected to have a solid basic knowledge of linear algebra, multivariate calculus, and probability theory, and a basic background in computer vision and machine learning. All practical projects will require solid background in programming and will be based on Python and libraries of it such as PyTorch.

Competencies

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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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263-5210-00L Probabilistic Artificial Intelligence

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming. The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Competencies

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<td>Decision-making</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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263-5300-00L Guarantees for Machine Learning

Abstract
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.
Objective

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work

- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions

- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project

- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Competencies

Subject-specific Competencies

Concepts and Theories
Assessed

Method-specific Competencies

Analytical Competencies
Assessed

Problem-solving
Assessed

Social Competencies

Communication
Assessed

Cooperation and Teamwork
Assessed

Personal Competencies

Creative Thinking
Assessed

Critical Thinking
Assessed

401-3054-14L Probabilistic Methods in Combinatorics W 5 credits 2V+1U B. Sudakov

Abstract

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content

The topics covered in the course will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

Literature

- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

401-3055-64L Algebraic Methods in Combinatorics W 5 credits 2V+1U not available

Abstract

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content

Combining combinatorics as a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

401-3621-00L Fundamentals of Mathematical Statistics W 9 credits 4V+1U J. Ziegel

Objective

Students are expected to have a mathematical background and should be able to write rigorous proofs.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1032 of 2667
Abstract In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

Objective The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.

Competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Problem-solving

Personal Competencies

Creative Thinking

401-3901-00L Linear & Combinatorial Optimization W 10 credits 4V+2U R. Zenklusen

Abstract Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content Key topics include:

- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature


Prerequisites / notice Solid background in linear algebra.

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Sensitivity to Diversity

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Tracks (all): Electives

This is only a short selection. Other courses from the ETH course catalogue may be chosen in agreement with your tutor.

As an alternative to the elective courses, students may do a second semester project or an internship in industry. Please consult your tutor.

Number Title Type ECTS Hours Lecturers

151-0371-00L Advanced Model Predictive Control W 4 credits 2V+1U M. Zeilinger, A. Carron, L. Hewing,
J. Köhler

Number of participants limited to 60.

Abstract Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

Objective Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

Content Topics include:

- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of regression methods
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

Lecture notes Lecture notes will be provided.

Prerequisites / notice Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control in Spring Semester) strongly recommended. Background in linear algebra and stochastic systems recommended.

351-0511-00L Managerial Economics W 4 credits 3V O. Krebs, P. Egger,
M. Köthenbürger

Not for MSc students belonging to D-MTEC!

Abstract "Managerial Economics" provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

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The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

Subject-specific Competencies
- Creative Thinking
- Communication
- Critical Thinking
- Analytical Competencies
- Decision-making

Analytical Competencies
- Social Competencies
- Self-presentation and Social Influence
- Cooperation and Teamwork
- Problem-solving
- Communication

Method-specific Competencies
- Business Competencies
- Self-direction and Self-management
- Critical Thinking
- Decision-making
- Analytical Competencies

Personal Competencies
- Self-direction and Self-management
- Critical Thinking
- Decision-making
- Analytical Competencies
- Problem-solving

Discovering Management (Pitch)

**Objective**

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

**Content**

The exercise consists of delivering and submitting a "pitch" with a clear recommendation for one of the selected cases amongst those seen in Discovering Management, using your insights from Discovering Management, and an extra session on pitching.

**Literature**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students have the option to either do this alone or in a group of two students.

**Prerequisites / notice**

The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

**Assessment**

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise. Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies
Communication assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management fostered

363-0790-00L Technology Entrepreneurship W 2 credits 2V F. Hacklin

Abstract
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding. This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

Objective
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Content
Weekly sessions - recorded.
10+ sessions carried out by guest lecturers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …). Final session: multiple choice semester assignment (100% of grade).

Typical lecture format (2h):
15': Introduction
60': Guest testimonial
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Lecture notes
Lecture slides and case material

Competencies

Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication fostered

Personal Competencies
Critical Thinking assessed

363-1082-00L Enabling Entrepreneurship: From Science to Startup W 3 credits 2V R. De Cock

Abstract
This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective
Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs.
2. The students can be from business or science & technology.
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea.

Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 25 September 2024 and apply to Robin De Cock: Robin.DeCock@uantwerpen.be.
Content

The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders' agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Lecture notes

Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

Literature

Book
Sethi, A. “From Science to Startup”
ISBN 978-3-319-30422-9

This course is relevant for those students who aspire to become entrepreneurs.

Prerequisites

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

851-0703-00L
Introduction to Law

W 2 credits 2V O. Streifn Göpfert

Abstract

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered. The focus is on legal problems related to space. Active participation is expected in short interactive sequences.

Objective

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law. They are able to apply the fundamentals in more advanced law classes and to recognize the relevance of law in their own field.

Content

Basic concepts of law, sources of law.
Private law: Contract law (particularly contract for work and services), tort law, property law.
Public law: Human rights, administrative law, procurement law, procedural law.
Insights into the law of the EU.

Lecture notes

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Further documents will be available online (https://moodle-app2.let.ethz.ch/course/view.php?id=22904).

851-0735-10L
Startups and Law

W 2 credits 2V P. Peyrot

Particularly suitable for students of D-ITET, D-MAVT.

Abstract

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective

The students shall obtain the following competences:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes

A comprehensive script will be made available online on the moodle platform.
The seminar aims to understand better what creativity and creative thinking is by looking at the history of the creativity dispositive we are fostered. In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

**Internship in Industry**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>227-1550-10L</td>
<td>Internship in Industry</td>
<td>W</td>
<td>12 credits</td>
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</table>

The main objective of the 12-week internship (full-time) is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

**Master Studies (Programme Regulations 2008)**

**Major Courses**

A total of 42 CP must be achieved during the Master Programme. The individual study plan is subject to the tutor's approval.

**Communication**

**Core Subjects**

These core subjects are particularly recommended for the field of "Communication".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0301-00L</td>
<td>Optical Communication Fundamentals</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U+1P</td>
<td>J. Leuthold</td>
</tr>
</tbody>
</table>
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.


Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.

Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes are handed out.

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Available at https://disco.ethz.ch/courses/des/

- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
- Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes are handed out.

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Recommended Subjects

These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

<table>
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<tr>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>227-0417-00L</td>
<td>Information Theory I</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>A. Lapidoth</td>
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</tbody>
</table>

Abstract

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Content


Number | Title                        | Type | ECTS | Hours |
-------|------------------------------|------|------|-------|
227-0102-00L | Discrete Event Systems     | W    | 6    | 4G    | L. Josipovic, L. Vanbever, R. Wattenhofer |

Abstract

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.

Objective

Over the past decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by exploring the limits of what is computable and what is not. In doing so, we will consider three distinct models of computation which are often used to model discrete event systems: finite automata, push-down automata and Turing machines (ranked in terms of expressiveness power). In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective; we model discrete events as stochastic processes, and then apply continuous time Markov chains and queueing theory for an understanding of the typical behavior of a system. Then we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queueing. In the last part of the course we introduce methods that allow to formally verify certain properties of finite automata and Petri Nets. These are some typical analysis questions we will look at: Do two given systems behave the same? Does a given system behave as intended? Does the system eventually enter a dangerous state?

Content

1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets

Lecture notes

Available at https://disco.ethz.ch/courses/des/
### Literature

**[bertsekas] Data Networks**  
Dimitri Bertsekas, Robert Gallager  

**[borodin] Online Computation and Competitive Analysis**  
Allan Borodin, Ran El-Yaniv  
Cambridge University Press, 1998

**[burch] Symbolic Model Checking**  
Inf. Comput. 98, 2 (June 1992), pp. 142-170

**[boudec] Network Calculus**  
J.-Y. Le Boudec, P. Thiran  
Springer, 2001

**[cassandras] Introduction to Discrete Event Systems**  
Christos Cassandras, Stéphane Lafortune  

**[fial] Online Algorithms: The State of the Art**  
A. Fiat and G. Woeginger

D. Hochbaum

**[murata] Petri Nets: Properties, Analysis and Applications**  
Tadao Murata  

**[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)**  
T. Schickinger, A. Steger  
Springer, Berlin, 2001

**[sipser] Introduction to the Theory of Computation**  
Michael Sipser  

### Competencies

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<td>Problem-solving</td>
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<td>Personal Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td>Critical Thinking</td>
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<td>Creative Thinking</td>
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</table>

### Prerequisites / notice

**227-0103-00L Control Systems**  
W 6 credits  
2V+2U  
F. Dörfler

**Abstract**  
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Objective**  
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Content**  

**Literature**  

**Prerequisites / notice**  
Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

---

**227-0116-00L VLSI 1: HDL Based Design for FPGAs**  
W 6 credits  
5G  
F. K. Gürkaynak

**Abstract**  
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

**Objective**  
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:

- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
  - Register Transfer Level (RTL) synthesis and its limitations.
  - Building blocks of digital VLSI circuits.
  - Functional verification techniques and their limitations.
  - Modular and largely reusable testbenches.
  - Assertion-based verification.
  - Synchronous versus asynchronous circuits.
  - The case for synchronous circuits.
  - Periodic events and the Anceau diagram.
  - Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes
Textbook and all further documents in English.

Literature

Prerequisites / notice
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

Further details:
https://lis-students.ee.ethz.ch/lectures/vlsi-i/

227-0166-00L
Analog Integrated Circuits

| W | 6 credits | 4G | T. Jang |

Abstract
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

Content
The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Lecture notes
Handouts of presented slides. No script but an accompanying textbook is recommended.

Literature

227-0301-00L
Optical Communication Fundamentals

| W | 6 credits | 2V+1U+1P | J. Leuthold |

Abstract
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

Objective
An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

Content
* Chapter 1: Introduction: Analog/Digital conversion. The communication channel, Shannon channel capacity, Capacity requirements.
  * Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
  * Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection teqchniques, Error correction coding.
  * Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
  * Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes
Lecture notes are handed out.

Literature

Prerequisites / notice
Basics of digital circuits.

227-0423-00L
Neural Network Theory

| W | 4 credits | 2V+1U | H. Bölcskei |

Abstract
Does not take place this semester.

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective
After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.
<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
<th>Content</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Universal approximation with single- and multi-layer networks</td>
<td>Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters. Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.</td>
</tr>
<tr>
<td></td>
<td>2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory</td>
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<td></td>
<td>3. Fundamental limits of deep neural network learning</td>
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<td></td>
<td>4. Geometry of decision surfaces</td>
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<td></td>
<td>5. Separating capacity of nonlinear decision surfaces</td>
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<td></td>
<td>6. Vapnik-Chervonenkis (VC) dimension</td>
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<td></td>
<td>7. VC dimension of neural networks</td>
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<td>8. Generalization error in neural network learning</td>
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<td></td>
<td>Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.</td>
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<td></td>
<td>This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.</td>
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<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>227-0468-00L</td>
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<tr>
<td>Objective</td>
<td>Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.</td>
<td>Suitable for Master Students as well as Doctoral Students.</td>
</tr>
<tr>
<td>Content</td>
<td>This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.</td>
<td>Suitable for Master Students as well as Doctoral Students.</td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Detailed lecture notes are available on the course web page <a href="https://www.mins.ee.ethz.ch/teaching/nt/">https://www.mins.ee.ethz.ch/teaching/nt/</a></td>
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<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>6 credits</td>
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<tr>
<td>227-0468-00L</td>
<td>Analog Signal Processing and Filtering</td>
<td>6 credits</td>
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<tr>
<td>W</td>
<td>E. Konukoglu, E. Erdi, F. Yu</td>
<td>H. Schmid</td>
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### Competencies

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<th>Competencies</th>
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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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</thead>
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<td>Analytical Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td></td>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Self-presentation and Social Influence</td>
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### Content

**Acoustics I**

**Abstract**
Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures.

**Objective**
Understanding of the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.

**Content**
Fundamentals of acoustics, calculation of sound fields, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, noise and noise control.

### Lecture notes

- Yes

### Competencies

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### Lecture notes

- No lecture notes, but slides will be made available on the course webpage.

### Literature

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### 263-4640-00L Network Security

**Abstract**
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems.

This course provides an in-depth study of network attack techniques and methods to defend against them.

- Students are familiar with fundamental network-security concepts.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

**Prerequisites / notice**
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

**Competencies**

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<td>Analytical Competencies</td>
<td>Communication</td>
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<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
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<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Integrity and Work Ethics</td>
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### 401-3055-64L Algebraic Methods in Combinatorics

**Abstract**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

- Students can implement network-security protocols based on cryptographic libraries.
- Students can identify and assess vulnerabilities in software systems and network protocols.

**Prerequisites / notice**
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L.

Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

**Prerequisites / notice**

### 227-0147-10L VLSI 3: Full-Custom Digital Circuit Design

**Abstract**
This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

- One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

- This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

**Lecture notes**
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

**Prerequisites / notice**
Students are expected to have a mathematical background and should be able to write rigorous proofs.
Adaptability and Flexibility

At the end of this course, you will
- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:
- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

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VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.
Objective
The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments.

Content
In 2023, the course will cover advanced topics in communication networks such as:
- Advanced Internet routing (convergence, optimality, scalability, flexibility);
- Network programmability (OpenFlow, P4);
- Traffic engineering / Load Balancing;
- Network verification and synthesis;
- Network measurements;
- Network security;
- Upcoming transport protocols and technologies;
- Adaptive video streaming; and
- Network sustainability.

The course will be composed of lectures and practical exercises (some of which including labs).

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<th>Competencies</th>
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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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227-0579-00L  Hardware Security  W  8 credits  2V+2U+2A  K. Razavi

Abstract
This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures and implementing some of these advanced attacks.

Objective
By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:
- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Lecture notes
Lecture notes and material will be made available before each course on the course website.

Literature
Relevant references will be made available through the course website.

Prerequisites / notice
Prerequisites: Communication Networks (227-0120-00L) or equivalents / programming skills (in any language) are expected (some of the exercises will involve coding).

252-1414-00L  System Security  W  7 credits  2V+2U+2A  S. Capkun, S. Shinde

Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.
Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Recommended Subjects
These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
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Abstract
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content
1. Discrete-time linear systems and filters; state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.
2. The discrete Fourier transform and its use for digital filtering.
3. The statistical perspective; probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes
Lecture Notes
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable.


Image segmentation. Motion extraction and tracking. 3D data extraction. Invariant features. Specific object recognition and object class recognition. Deep learning and Convolutional Neural Networks.
Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

227-0555-00L Distributed Systems W 4 credits 3G+1A R. Wattenhofer

Enrolled students will be notified by e-mail about the lecture start.

Abstract
This course introduces the fundamentals of distributed systems. We study different protocols and algorithms that allow for fault-tolerant operation, and discuss practical systems that implement these techniques.

Objective
The objective of the course is for students to understand the theoretical principles and practical considerations of distributed systems. This includes the main models of fault-tolerant distributed systems (crash failures, byzantine failures, and selfishness), and the most important algorithms, protocols and impossibility results. By the end of the course, students should be able to reason about various concepts such as consistency, durability, availability, fault tolerance, and replication.

Content
We discuss the following concepts related to fault-tolerant distributed systems: client-server, serialization, two-phase protocols, three-phase protocols, Paxos, two generals problem, crash failures, impossibility of consensus, byzantine failures, agreement, termination, validity, byzantine agreement, king algorithm, asynchronous Byzantine agreement, authentication, signatures, reliable and atomic broadcast, eventual consistency, blockchain, cryptocurrencies such as Bitcoin and Ethereum, proof-of-work, proof-of-, smart contracts, quantum systems, fault-tolerant protocols such as p2Chain or pbft, distributed storage, distributed hash tables, physical and logical clocks, causality, selfishness, game theoretic models, mechanism design.

Lecture notes
A script is available on the web page.

Literature
The script is self-contained, but links to additional material are available on the web page.

Prerequisites / notice
This lecture takes place in roughly the second half of the semester, as the lecture is the second part of the lecture "Computer Systems" (252-0217-00L). Students may attend at most one of the two lectures, NOT both.

227-2210-00L Computer Architecture W 8 credits 6G+1A S. Sadrosadati, O. Mutlu

Abstract
Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective
We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g., graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content
The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

Lecture notes
All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

The video recordings of the lectures are expected to be made available after lectures.

See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

Literature
We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

See https://safari.ethz.ch/architecture for past examples.

Prerequisites / notice

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Problem-solving assessed
Communication assessed
Leadership and Responsibility assessed
Adaptability and Flexibility assessed
Critical Thinking assessed
Self-direction and Self-management assessed

Method-specific Competencies

Social Competencies

Personal Competencies

151-0593-00L Embedded Control Systems W 4 credits 6G C. Onder, M. Schmid Daners

Abstract
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

Objective
Familiarize students with main architectural principles and concepts of embedded control systems.
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

The application of C-programming on a microprocessor is mandatory. Specific knowledge of C is not required. A basic understanding of security (e.g., as taught in 252-0211.00L Information Security) is recommended.

Detailed information can be found on the course website:
http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

The course website can be found at
https://moodle-app2.let.ethz.ch/course/view.php?id=15757

The course can be booked via the course website. After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Does not take place this semester.

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Waring theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at
https://moodle-app2.let.ethz.ch/course/view.php?id=15757

These core subjects are particularly recommended for the field of "Electronics and Photonics".

### Core Subjects

#### Autumn Semester 2024

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0146-00L</td>
<td>Data Conversion System Design</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>T. Burger, G. Cervelli, R. Reutemann</td>
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This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.
Objective
Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. Students will learn the underlying principles of data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or algorithmic conversion are explained based on their operation principle accompanied with the appropriate mathematical calculations, including effects of non-idealities in some cases. After successful completion of the course students should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.

Content
- Introduction: examples of data conversion architectures; information representation; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy
- Dual-slope & successive approximation register (SAR) converters; dual slope principle & converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.
- Algorithmic & pipelined A/D converters; algorithmic conversion principle; sample & hold stage; pipe-lined converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.
- Performance metrics and non-linearity: ideal ADC; offset; gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.
- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkle correction; limitations of flash converters: the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters; cascaded folding and interpolation.
- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, KTC/noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.
- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-order delta-sigma modulation, circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.

Lecture notes
Slides are available online under https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/

Literature
- M. Gustavsson et. al., CMOS Data Converters for Communications, Springer, 2010

Prerequisites / notice
This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies

Method-specific Competencies
- Analytical Competencies

227-0147-10L VLSI 3: Full-Custom Digital Circuit Design

Abstract
This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

Objective
At the end of this course, you will
- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

Content
- The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:
  - Nanometer MOSFETs
  - Static and dynamic behavior of complementary MOS (CMOS) inverters
  - CMOS gate design, sizing, and timing
  - Full-custom standard-cell design
  - Wire models and parasitics
  - Latch and flip-flop circuits
  - Gate-level timing analysis and optimization
  - Static and dynamic power consumption; low-power techniques
  - Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
  - Arithmetic and logic circuits
  - Fixed-point and floating-point arithmetic
  - Synchronous and asynchronous design principles
  - Memory circuits (ROM, SRAM, and DRAM)
  - In- and near-memory processing architectures
  - Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

Lecture notes
Slides are available online under https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/

Literature
- N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

Prerequisites / notice
It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies

Method-specific Competencies
- Analytical Competencies

227-0301-00L Optical Communication Fundamentals

Abstract
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

Objective
An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.
Content

* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.


* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.

* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

* Chapter 7: Optical Amplifiers : Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes are handed out.

**Prerequisites / notice**


**Lecture notes**

**Literature**

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

**Course Schedule**

<table>
<thead>
<tr>
<th>Module (Module Code)</th>
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<th>Language</th>
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<tbody>
<tr>
<td>227-0517-10L</td>
<td>Fundamentals of Electric Machines</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>D. Bortis</td>
</tr>
</tbody>
</table>
| **Abstract** | This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

**Objective** | The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

**Content**

- Fundamentals in magnetic circuits and electromagnetic energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

**Lecture notes**

Lecture notes and associated exercises including correct answers

**Competencies**

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

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<tr>
<td>227-0663-00L</td>
<td>Nano-Optics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>M. Frimmer</td>
</tr>
</tbody>
</table>
| **Abstract** | Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

**Objective** | Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

**Content**

- Electromagnetic fields and waves (or equivalent)
- Physics I+II

**Prerequisites / notice**

- Electromagnetic fields and waves (or equivalent)
- Physics I+II

**Course Schedule**

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<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W</td>
<td>6 credits</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu, M. Payvand</td>
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| **Abstract** | This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective** | Understanding of the characteristics of neuromorphic circuit elements.
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Recommended Subjects

These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number Title Type ECTS Hours Lecturers
227-0111-10L Communication Electronics II W 6 credits 2V+2U H. Wang
227-0121-00L Communication Systems W 6 credits 4G C. Studer, S. M. Moser
227-0155-00L Machine Learning on Microcontrollers W 6 credits 4G M. Magno

Registration in this class requires the permission of the instructors. Preference is given to students in the MSc EEIT.

Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly “smart”. This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the “internet-of-things”, using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.
Content

The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercises will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Lecture notes Script and exercise sheets. Books will be suggested during the course.
Prerequisites / notice Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable.

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<td>227-0157-00L</td>
<td>Semiconductor Devices: Physical Bases and Simulation</td>
<td>4</td>
<td>G</td>
<td>A. Schenk, C. I. Roman</td>
</tr>
<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
<td>6</td>
<td>G</td>
<td>T. Jang</td>
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<tr>
<td>227-0377-10L</td>
<td>Physics of Failure and Reliability of Electronic Devices and Systems</td>
<td>3</td>
<td>V</td>
<td>I. Shorubalko, M. Held</td>
</tr>
<tr>
<td>227-0443-00L</td>
<td>Space Communications</td>
<td>4</td>
<td>V+2U</td>
<td>J. Smajic, M. Burla, J. Leuthold, R. Muff, C. Studer, H. Wang</td>
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Abstract

The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

The course aims at understanding the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The theorems are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

The course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

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The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

The laboratory exercises will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

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Abstract

The course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

This course offers a comprehensive overview of challenges on communication equipment imposed by space flight missions, and (c) to review existing and future communication technologies for inter-satellite links, inter-spacecraft links, as well as low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The course aims at understanding the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

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The laboratory exercises will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Lecture notes Script and exercise sheets. Books will be suggested during the course.
Prerequisites / notice Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable.

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This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.
Simulation of Photovoltaic Devices - From Materials to Concepts and Theories

Objective
Get an overview of the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to analyze, optimize, and predict the performance of solar cells and modules.

Content
Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules, Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture)

Literature

Prerequisites
Undergraduate physics (including basic quantum mechanics), mathematics, semiconductor devices, optics. Knowledge of some scripting language (e.g. python) is of advantage.

Literature

Prerequisites
Undergraduate physics (including basic quantum mechanics), mathematics, semiconductor devices, optics. Knowledge of some scripting language (e.g. python) is of advantage.

Literature
This lecture provides theoretical and experimental knowledge on the techniques for the characterization and numerical modeling of power semiconductor devices, as well as on the related built-in reliability strategies.

The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems.

This lecture consists of a theoretical part (50%) and of laboratory exercises and demonstrations (50%). The theoretical part covers the basic techniques and procedures for characterization, modeling and built-in reliability of modern power semiconductor devices with special attention to MOS and IGBT. The starting part on technology provides an overview on the main device families and includes a review of the most relevant application-oriented aspects of the device physics, thermal management, and packaging. The second section deals with the basic experimental characterization techniques for the definition of the semiconductor material properties, electrical characteristics, safe operating area, and junction temperature of the devices. The following section introduces the basic principles for electrical, thermal, and electro-thermal simulation of power semiconductors by Technology Computed Aided Design (TCAD) and compact modeling. Finally, procedures are methods are presented to implement efficient built-in reliability programs targeted on power semiconductors. They include failure physics, dedicated failure analysis techniques, accelerated testing, defect screening, and lifetime modeling.

During the laboratory activities, selections of the experimental techniques presented in the lecture are demonstrated on the base of realistic examples. Furthermore, schematic power devices will be simulated by the students with advanced TCAD tools and circuit simulators.

Handouts to the lecture (approx. 250 pp.)

Eiichi Ohno: "Introduction to Power Electronics"
B. Murari et al.: "Smart Power ICs"
B. J. Baliga: "Physics Modern Power Devices"
S. K. Ghandi: "Semiconductor Power Devices"

Be motivated to change the world to renewable energies!

A visit to Empa's Energy Conversion and Storage Labs will be organized during the semester. Possibility to interact and meet your classmates from EPFL via online lecture platform and during two special lectures with guest lecturers from industry (one guest lecture by ABB at ETH Zurich, one guest lecture by Northvolt at EPFL). Travel expenses for students will be covered.

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Elements of calculus will be reviewed during the lectures, where necessary, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing an intuitive understanding on how to interpret the most important device characteristics.

Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students.

The measurement process is at the heart of both science and engineering. Measurement precision is ultimately limited by the laws of quantum mechanics. This course provides the knowledge necessary to understand current state-of-the-art quantum measurement systems operating at their fundamental limits with a particular focus on optomechanical implementations.

The goal of this course is to understand the quantum limits of measurement precision together with a formal description of the measurement process in the framework of quantum mechanics.

The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. We discuss the “standard quantum limit” as it arises from the balance of measurement imprecision and backaction, before turning to approaches to overcome it and reach the fundamental “Heisenberg limit”. The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics. Exercises serve to consolidate our understanding and insight.
Analytical Competencies
The presentation slides and further material will be provided every week.

The objective of this course is to understand how the electronic properties of carbon-based materials can be exploited for fabricating quantum devices. We will delve into both the theoretical and experimental aspects, discussing how these materials' unique properties can be translated into device functionality.

On the theoretical side, we'll cover how the chemical structure of the material and its dimensionality, ranging from 0D to 2D, affects the electronic properties. We'll also discuss how charge carriers flow through the devices and what charge transport mechanisms are at play.

On the experimental side, we'll cover how such devices are fabricated, including how the materials are synthesized. We'll also discuss how to characterize the devices and assess their performance.

Subject-specific Competencies
The course will cover the following carbon-based materials:
- Single-molecule
- Graphene (single layer, bilayer, twisted bilayer)
- Graphene nanoribbons
- Carbon nanotubes

For each material, we will discuss:
- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

The course also includes a presentation by each student in which a related scientific publication is discussed. This presentation is compulsory and accounts for 30% of the grade.

Lecture notes
Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

Literature
In addition to the slides, the following supplementary books can be recommended:

Prerequisites /
A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

Content
The course will cover the following carbon-based materials:

- Carbon nanotubes
- Graphene nanoribbons
- Graphene (single layer, bilayer, twisted bilayer)
- Single-molecule

For each material, we will discuss:
- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

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- Concepts and Theories
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Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

Content
The course will cover the following carbon-based materials:
- Single-molecule
- Graphene (single layer, bilayer, twisted bilayer)
- Graphene nanoribbons
- Carbon nanotubes

For each material, we will discuss:
- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

The course also includes a presentation by each student in which a related scientific publication is discussed. This presentation is compulsory and accounts for 30% of the grade.

Lecture notes
Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

Literature
In addition to the slides, the following supplementary books can be recommended:

Prerequisites /
A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FD), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

Prerequisites / notice

Basic knowledge of solid state physics and semiconductors.

Competencies

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227-2037-00L Physical Modelling and Simulation

Objective

Content

227-2037-00L Physical Modelling and Simulation

Objective

Content

151-0620-00L Embedded MEMS Lab

Objective

Content

151-0620-00L Embedded MEMS Lab

Objective

Content

363-0389-00L Technology and Innovation Management

Objective

Content

363-0389-00L Technology and Innovation Management

Objective

Content
Adaptability and Flexibility fostered

Will be distributed via moodle.
Slides will be available on the Moodle page

The course content and methods are designed for students with some background in management and/or economics

Competencies

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Abstract

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments.
- Spaces of polynomials and tensor product methods.
- Siegel’s theorem.
- Applications such as: Solution of Kakeya problem in finite fields.
- Counterexample to Borsuk’s conjecture.
- Chromatic number of the unit distance graph of Euclidean space.
- Explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice

Students are expected to have a mathematical background and should be able to write rigorous proofs.

402-0475-00L Algebraic Methods in Combinatorics

Does not take place this semester.

Abstract

Terahertz Science and Applications

The Terahertz (THz) range (0.1 – 10 THz), lies between the infrared and microwave spectral regions and has become accessible in the past few years. This new capability has had great impact in scientific research, and has led to technological advances and to the development of a variety of applications and devices. This course provides an introduction to THz science, technology and applications.

Objective

The goal of this course is to enable students to determine whether a THz solution can be applied to a particular scientific or technological problem. Armed with the fundamentals of THz science and of current THz technologies, covered in this introductory course, students will be able to weigh the capabilities, advantages and limitations of THz tools to address topics ranging from phonons in solid state systems and molecular vibrations in solutions to medical imaging and wireless communications.

Lecture notes

Will be distributed via moodle.

Literature

Yun-Shik Lee, Principles of Terahertz Science and Technology, Springer 2009

Additional references distributed via moodle.

Prerequisites / notice

Basic knowledge in physics, especially in electromagnetism, is required. No formal prerequisites.

Competencies

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</table>

Energy and Power Electronics
The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify of weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

- discussion of the field equations relevant for high voltage engineering,
- analytical and numerical solutions/solving of these equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations
- introduction to kinetic gas theory
- mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems
- methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations
- application of the expertise on high voltage components
- excursions to manufacturers of high voltage components

### Lecture notes
Lecture Slides

### Literature

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### Prerequisites / notice
Prerequisites: Introductory course on power electronics is recommended.

### Lecture notes
Lecture notes and associated exercises including correct answers.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: fostered

#### Personal Competencies
- Creative Thinking: fostered

### Prerequisites / notice
Prerequisites: Introductory course on power electronics is recommended.

### Lecture notes
Lecture notes.

### Core Subjects
These core subjects are particularly recommended for the field of “Energy and Power Electronics”.

<table>
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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<td>227-0117-00L</td>
<td>High Voltage Engineering</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>C. Franck, U. Straumann</td>
</tr>
<tr>
<td>227-0247-00L</td>
<td>Power Electronic Systems I</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>J. Biela, F. Krismer</td>
</tr>
<tr>
<td>227-0526-00L</td>
<td>Power System Analysis</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>G. Hug</td>
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</table>

### Abstract
- High electric fields are used in numerous technological and industrial applications such as electric power transmission and distribution, X-ray devices, DNA sequencers, flue gas cleaning, power electronics, lasers, particle accelerators, copying machines, ... High Voltage Engineering is the art of gaining technological control of high electrical field strengths and high voltages.
- The goal of this course is understanding the stationary dependencies in electrical power systems and the application of analysis tools in the lecture Power Electronic Systems II.
- The goal of this course is understanding the stationary dependencies in electrical power systems and the application of analysis tools in normal but also in faulty state.
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### Objective
- Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems.
- Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.
- The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.
- Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis and symmetrical components are discussed as well as power flow computation techniques for distribution grids and state estimation.

### Content
- Basics of the switching behavior and gate drive circuits of power semiconductors are discussed. Soft-switching and resonant DC/DC converters are analyzed in detail and high frequency loss mechanisms of magnetic components are explained. Space vector modulation of three-phase inverters is introduced and the main power components are designed for typical industry applications.
- Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail.
- The operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.

### Lecture notes
Lecture notes.
The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol interference, detection theory, as well as the basics of forward error correction and information theory.

Content
- analog and digital modulation
- baseband and passband representation; up- and down-conversion
- communication channels as LTI systems
- discretizing communication systems; sampling and quantization
- noise, signal-to-noise ratio (SNR), and interference
- detection theory and error rates
- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.

Lecture notes
Lecture notes will be distributed electronically at the beginning of the semester.

Literature

Prerequisites / notice
Available on the course Moodle platform.
### 227-0523-00L  Railway Systems I

**W 6 credits  4G  M. Meyer**

**Abstract**
Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance

**Objective**
- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

**Content**
1 Einführung:
1.1 Geschichte und Struktur des Bahnsystems
1.2 Fahrdynamik
2 Vollbahnfahrzeuge:
2.1 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
2.2 Bremsen
2.3 Traktionsantriebssysteme
2.4 Hilfsbetriebe und Komfortanlagen
2.5 Steuerung und Regelung
3 Infrastruktur:
3.1 Fahrweg
3.2 Bahnstromversorgung
3.3 Sicherungsanlagen
4 Betrieb:
4.1 Interoperabilität, Normen und Zulassung
4.2 RAMS, LCC
4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

**Lecture notes**
Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

**Prerequisites / notice**
Dozent:
Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

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### 227-0536-00L  Multiphysics Simulations for Power Systems

**W 4 credits  2V+2U  J. Smajic**

**Abstract**
The goals of this course are a) understanding the fundamentals of the electromagnetic, thermal, mechanical, and coupled field simulations and b) performing effective simulations of primary equipment of electric power systems. The course is understood complementary to 227-0537-00L “Technology of Electric Power System Components”, but can also be taken separately.

**Objective**
The student should learn the fundamentals of the electromagnetic, thermal, mechanical, and coupled fields simulations necessary for modern product development and research based on virtual prototyping. She / he should also learn the theoretical background of the finite element method (FEM) and its application to low- and high-frequency electromagnetic field simulation problems. The practical exercises of the course should be done by using one of the commercially available field simulation software (Infolytica, ANSYS, and / or COMSOL).

After completing the course the student should be able to properly and efficiently use the software to simulate practical design problems and to understand and interpret the obtained results.
Content
1. Electromagnetic Fields and Waves: Simulation Aspects (1 lecture, 2 hours)
a. Short review of the governing equations
b. Boundary conditions
c. Initial conditions
d. Linear and nonlinear material properties
e. Coupled fields (electro-mechanical and electro-thermal coupling)

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
a. Dielectric analysis of high-voltage equipment
b. Nonlinear quasi-electrostatic analysis of surge arresters
c. Eddy-currents analysis of power transformers
d. Electromagnetic analysis of electric machines
e. Very fast transients in gas insulated switchgears (GIS)
f. Electromagnetic compatibility (EMC)

227-0567-00L Design of Power Electronic Systems W 6 credits 4G F. Krismer

Abstract
Complete design process: from given specifications to a complete power electronic system; selection / design of suitable passive power components; static and dynamic properties of power semiconductors; optimized EMI filter design; heat sink optimization; additional circuitry, e.g. gate driver; system optimization.

Objective
Basic knowledge of design and optimization of a power electronic converter system; furthermore, lecture and exercises thoroughly discuss key subjects of power electronics that are important with respect to a practical realization, e.g. how to select or design suitable power components, to understand switching operations, calculation of high frequency losses, EMI filter design and realization, thermal considerations.

Content
Complete design process: from given specifications to a complete power electronic system.
Selection and / or design of suitable passive power components: specific properties, parasitic components, tolerances, high frequency losses, thermal considerations, reliability.
Static and dynamic characteristics of power semiconductors.
Optimized design of the EMI filter.
Thermal characterization of the converter, optimized heat sink design.
Additional circuitry: gate driver, measurement, control.
Converter start up: typical sequence of events, circuitry required.
Overall system optimization: identifying couplings between different components of the considered power electronic system, optimization targets and issues.

Lecture notes
Lecture notes and complementary exercises including correct answers.

Prerequisites / notice
Prerequisites: Introductory course on power electronics.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed
Method-specific Competencies
Analytical Competencies
Decision-making
assessed
Problem-solving
fostered
Personal Competencies
Adaptability and Flexibility
Creative Thinking
fostered
Critical Thinking
fostered

227-0561-00L Solar Cells W 4 credits 3G Y. Romanyuk, R. Carron

Abstract
Physics, technology, characteristics and applications of photovoltaic solar cells and systems.

Objective
The students will appreciate the potential of solar radiation and photovoltaics, will learn the physics and technology of various solar cells, and will get to know the design basics of PV modules and systems for different applications.

Content
Introduction to photovoltaics and economic aspects, solar radiation, semiconductor physics and operation of solar cells, technology of water-based (Si, GaAs, multi-junction) and thin-film (CIGS, CdTe, copper-white) solar cells, emerging technologies, design of PV modules, systems and plants including system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples such concentrated photovoltaics and power generation for space applications.

Lecture notes
Lecture slides (PDF files in English) will be available on Moodle and lecture recordings will be available on the ETH video portal.

Prerequisites / notice
Prerequisites: Basic knowledge of semiconductors.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed

227-0618-00L Modeling, Characterization and Reliability of Power Semiconductors W 6 credits 4G

Abstract
This lecture provides theoretical and experimental knowledge on the techniques for characterization and numerical modeling of power semiconductors, as well on the related built-in reliability strategies.

Objective
The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power electronic devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems.

Content
This lecture consists of a theoretical part (50%) and of laboratory exercises and demonstrations (50%).
The theoretical part covers the basic techniques and procedures for characterization, modeling and built-in reliability of modern power semiconductor devices with special attention to MOS and IGBT. The starting part on technology provides an overview on the main device families and includes a review of the most relevant application-oriented aspects of the device physics, thermal management, and packaging. The second section deals with the basic experimental characterization techniques for the definition of the semiconductor material properties, electrical characteristics, safe operating area, and junction temperature of the devices. The following section introduces the basic principles for electrical, thermal, and electro-thermal simulation of power semiconductors by Technology Computed Aided Design (TCAD) and compact modeling. Finally, procedures are methods are presented to implement efficient built-in-reliability programs targeted on power semiconductors. They include failure physics, dedicated failure analysis techniques, accelerated testing, defect screening, and lifetime modeling.
During the laboratory activities, selections of the experimental techniques presented in the lecture are demonstrated on the base of realistic examples. Furthermore, schematic power devices will be simulated by the students with advanced TCAD tools and circuit simulators.
### 227-0619-00L Charge Transport in Energy Conversion and Storage

**W** 6 credits 2V+2U C. Battaglia, A. Senocrate

**Abstract**

The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolysers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in electrical engineering, materials science, physics, and chemistry.

**Objective**

By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolysers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

**Literature**


R. Huggins, Advanced Batteries, DOI:10.1007/9780387764245

**Prerequisites / notice**

Be motivated to change the world to renewable energies!

This course is taught simultaneously at ETH Zurich and EPFL. All lectures will be recorded live from ETH Zurich with four lectures taught onsite at EPFL Lausanne.

A visit to Empa's Energy Conversion and Storage Labs will be organized during the semester. Possibility to interact and meet your classmates from EPFL via online lecture platform and during two special lectures with guest lecturers from industry (one guest lecture by ABB at ETH Zurich, one guest lecture by Northvolt at EPFL). Travel expenses for students will be covered.

Elements of calculus will be reviewed during the lectures, where necessary, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite.

Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students.

Lectures will be streamed live from ETH Zurich with four lectures taught onsite at EPFL Lausanne.

A visit to Empa's Energy Conversion and Storage Labs will be organized during the semester. Possibility to interact and meet your classmates from EPFL via online lecture platform and during two special lectures with guest lecturers from industry (one guest lecture by ABB at ETH Zurich, one guest lecture by Northvolt at EPFL). Travel expenses for students will be covered.

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Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students.
Content

1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX

2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions

3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   2.8. Risk Management 3 (enterprise wide)

4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

Lecture notes
Handouts of the lecture
Prerequisites /
notice
Case studies and ML exercise for Power Market can give bonus points for the exam. Guest speakers for specific topics.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered

Core Subjects
These core subjects are particularly recommended for the field of "Systems and Control".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>J. Lygeros, A. Tsiamis</td>
</tr>
<tr>
<td>Abstract</td>
<td>The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.</td>
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</tbody>
</table>
| Content    | - Proof techniques and practices.  
|            | - Linear spaces, normed linear spaces and Hilbert spaces.  
|            | - Ordinary differential equations, existence and uniqueness of solutions.  
|            | - Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.  
|            | - Controllability and observability, duality. Time invariant systems treated as a special case.  
|            | - Stability and stabilization, observers, state and output feedback, separation principle. |
| Lecture notes | Available on the course Moodle platform. |
| Prerequisites / notice | Sufficient mathematical maturity, in particular in linear algebra, analysis. |
| Competencies | Subject-specific Competencies|
|              | Concepts and Theories assessed |
|              | Techniques and Technologies assessed |
| Method-specific Competencies | Analytical Competencies assessed |
|              | Problem-solving assessed |
| Personal Competencies | Creative Thinking fostered |
|              | Critical Thinking fostered |
|              | Integrity and Work Ethics fostered |

| 227-0697-00L | Industrial Process Control | W    | 4    | 3G    | A. Horch, L. Dominguez Palomeque |
| Abstract     | Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing. General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends. |
| Objective    | |

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Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering. Differences and characteristics of discrete and process industries.

Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry.

Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequence control, structured text); PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabling, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus); Ergonomic design, safety (IEC61508) and availability, supervision and diagnosis.

Automation standards: Communication, Architecture, Engineering, dependable systems, functional safety, automation security.

Extensive practical examples from different process industries, power generation, gas compressor control, and automotive manufacturing.

Slides will be available as .PDF documents, see "Learning materials" (for registered students only).

Type
Introduction to Dynamic Programming and Optimal Control.

ECTS
6 credits

Dynamic Programming and Optimal Control

R. D'Andrea

Number
227-0102-00L

Title
Discrete Event Systems

Type
W


Literature

Prerequisites / notice

Content

Abstract
Introduction to discrete event systems. We start out the course by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by exploring the limits of what is computable and what is not. In doing so, we will consider three distinct models of computation which are often used to model discrete event systems: finite automata, push-down automata and Turing machines (ranked in terms of expressiveness power). In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply continuous time markov chains and queuing theory for an understanding of the typical behavior of a system. Then we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing. In the last part of the course we introduce methods that allow to formally verify certain properties of Finite Automata and Petri Nets. These are some typical analysis questions we will look at: Do two given systems behave the same? Does a given system behave as intended? Does the system eventually enter a dangerous state?

Content

1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets

Lecture notes
Available at https://disco.ethz.ch/courses/des/
<table>
<thead>
<tr>
<th>Literature</th>
</tr>
</thead>
</table>
| [bertsekas] | Data Networks
Dimitri Bertekas, Robert Gallager
| [borodin] | Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv.
Cambridge University Press, 1998 |
| [burch] | Symbolic Model Checking
Inf. Comput. 98, 2 (June 1992), pp. 142-170 |
| [boudec] | Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001 |
| [cassandras] | Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune.
| [fiat] | Online Algorithms: The State of the Art
A. Fiat and G. Woeginger |
D. Hochbaum |
| [murata] | Petri Nets: Properties, Analysis and Applications
Tadao Murata
| [schickinger] | Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001 |
| [sipser] | Introduction to the Theory of Computation
Michael Sipser.

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<td>Communication</td>
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<td>Critical Thinking</td>
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<th>Credits</th>
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<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>6</td>
<td>3V+1U</td>
<td>E. Konukoglu, E. Erdil, F. Yu</td>
<td></td>
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<tr>
<td>227-0526-00L</td>
<td>Power System Analysis</td>
<td>6</td>
<td>4G</td>
<td>G. Hug</td>
<td></td>
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</tbody>
</table>

**Abstract**

**Image Analysis and Computer Vision**

**Objective**
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Content**
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Lecture notes**
Course material Script, computer demonstrations, exercises and problem solutions

**Prerequisites / notice**
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
The course language is English.

**Power System Analysis**
The goal of this course is understanding the stationary dependencies in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

**Objective**
The goal of this course is understanding the stationary dependencies in electrical power systems and the application of analysis tools in normal but also in faulty state.

**Content**
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis and symmetrical components are discussed as well as power flow computation techniques for distribution grids and state estimation.

**Lecture notes**
Lecture notes.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies fostered
Problem-solving assessed
Personal Competencies
Critical Thinking fostered

227-0689-00L System Identification W 4 credits 2V+1U R. Smith
Abstract
Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.
Objective
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.
Content

Literature
Prerequisites / notice
Control systems (227-0216-00L) or equivalent.

151-0532-00L Nonlinear Dynamics and Chaos I W 4 credits 4G G. Haller
Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.
Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.
Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance
Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.
Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D'Andrea
Abstract
Introduction to Dynamic Programming and Optimal Control.
Objective
Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.
Literature
Prerequisites / notice
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions W 3 credits 2V R. Riener, O. Lambercy
Abstract
Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.
Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Content

Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature

Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice

Target Group:
Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
Students of other departments, faculties, courses are also welcome
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

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### Competencies

<table>
<thead>
<tr>
<th>Subjects-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<td>Personal Competencies</td>
<td>Leadership and Responsibility</td>
<td>fostered</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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</tbody>
</table>

### Literature

**Introduction to Mathematical Optimization**
- R. Zenklusen

**Linear & Combinatorial Optimization**
- J. Stelling

**Computational Systems Biology**
- D. Adjiashvili

### Prerequisites / notice

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

### Abstract

**Introduction to Mathematical Optimization**
- Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

**Linear & Combinatorial Optimization**
- Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Computational Systems Biology**
- Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

### Prerequisites

- Solid background in linear algebra.
- 6 credits
- 10 credits
- 5 credits

### Objective

- The goal of this course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.
- The goal of the course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.
- The aim of this course is to provide an introductory overview of corresponding methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

### Content

**Introduction to Mathematical Optimization**
- Topics covered in this course include:
  - Linear programming (simplex method, duality theory, shadow prices, ...).
  - Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
  - Modelling with mathematical optimization: applications of mathematical programming in engineering.

**Linear & Combinatorial Optimization**
- Key topics include:
  - Linear programming and polyhedra;
  - Flows and cuts;
  - Combinatorial optimization problems and polyhedral techniques;
  - Equivalence between optimization and separation.

**Computational Systems Biology**
- Biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

### Notice

- Information about relevant literature will be given in the lecture.
- Data: 02.07.2024 12:39
- Lecture notes: [http://www.csb.ethz.ch/education/lectures.html](http://www.csb.ethz.ch/education/lectures.html)
The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation - Introduction to Estimation and Machine Learning

E. Erdil, F. Yu

Title

Neural Network Theory

Core Subjects

Introduction to Estimation and Machine Learning

Number

227-0105-00L

Title

Introduction to Estimation and Machine Learning

Abstract

Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

Objective

Students master the basic mathematical concepts and algorithms of estimation and machine learning.

Content

Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more.

Lecture notes

Lecture notes will be handed out as the course progresses.

Prerequisites / notice

solid basics in linear algebra and probability theory

Number

227-0423-00L

Title

Neural Network Theory

Abstract

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

Content

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

Lecture notes

Detailed lecture notes are available on the course web page

Prerequisites / notice

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

Number

227-0447-00L

Title

Image Analysis and Computer Vision

Abstract


Literature


Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

Prerequisites / notice

ECTS
W
W
Type
4G
H.
Hours
C. Cotrini Jimenez

227-0101-00L
Advanced Machine Learning
W
10 credits
3V+2U+4A
C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
What is data?
Bayesian Learning
Computational learning theory

Supervised learning:
Ensembles: Bagging and Boosting
Max Margin methods
Neural networks

Unsupervised learning:
Dimensionality reduction techniques
Clustering
Mixture Models
Non-parametric density estimation
Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Prerequisites

Literature


PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

Recommended Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

Abstract
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.
Content

1. Discrete-time linear systems and filters:
   state-space realizations, z-transform and spectrum,
   decimation and interpolation, digital filter design,
   stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
   probability, random variables, discrete-time stochastic processes;
   detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
   Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

227-0116-00L  VLSI 1: HDL Based Design for FPGAs  W  6 credits  5G  F. K. Gürkaynak

Abstract

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:

- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICS compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes

Textbook and all further documents in English.

Prerequisites

- Basics of digital circuits.

Further details:

https://iis-students.ee.ethz.ch/lectures/vlsi-i/

227-0121-00L  Communication Systems  W  6 credits  4G  C. Studer, S. M. Moser

Abstract

The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol interference, detection theory, as well as the basics of forward error correction and information theory.

Objective

After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to:

- understand the fundamentals of digital communication systems
- explain the principles of modulation, demodulation, detection, and error correction
- analyze error rates of simple digital communication systems
- implement simple MATLAB simulations to calculate error rates

Content

The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the main building blocks of modern digital communication systems. The topics include:

- essential components of digital communication systems
- analog and digital modulation
- baseband and passband representation; up- and down-conversion
- communication channels as LTI systems
- discretizing communication systems; sampling and quantization
- noise, signal-to-noise ratio (SNR), and interference
- detection theory and error rates
- basics of forward error correction
- basics of information theory
- orthogonal frequency-division multiplexing (OFDM)
- building blocks of modern communication systems

The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.

Lecture notes

Lecture notes will be distributed electronically at the beginning of the semester.

Literature

Subject-specific Competencies

Machine Learning on Microcontrollers

Registration in this class requires the permission of the instructors.

Preference is given to students in the MSc EEIT.

Abstract

Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly ‘smart’. This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the “internet-of-things”, using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

Objective

Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

Content

The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Lecture notes

Script and exercise sheets. Books will be suggested during the course.

Prerequisites

Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable

Linear System Theory

W 6 credits 4G J. Lygeros, A. Tsiamis

Abstract

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes

Available on the course Moodle platform.

Prerequisites

Sufficient mathematical maturity, in particular in linear algebra, analysis.

Information Theory I

W 6 credits 4G A. Lapidoth

Abstract

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equipartition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective

The fundamentals of Information Theory including Shannon’s source coding and channel coding theorems

Content

The entropy rate of a source, Typical sequences, the asymptotic equipartition property source, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Learning in Deep Artificial and Biological Neuronal Networks

W 4 credits 3G B. Grewe

Abstract

Deep-Learning (DL) a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.
The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world.

However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

The lecture slides will be provided as a PDF after each lecture.

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

**Content**

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically and computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

**Prerequisites / notice**

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

**Competencies**

The students should have:

- a very strong mathematical background (real analysis, probability theory, linear algebra)
- solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”.
- Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

**Literature**


**Course website**

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

**Lecture notes**

Lectures will be posted on the blackboard, but there will be a set of typeset lecture notes which follow the class closely.
Students are expected to have a mathematical background and should be able to write rigorous proofs.

401-3621-00L Fundamentals of Mathematical Statistics

Abstract
In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

Objective
The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

401-3901-00L Linear & Combinatorial Optimization

Abstract
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective
The goal of this course is to gain a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature

Prerequisites / notice
Solid background in linear algebra.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Subjects of General Interest
These courses are suitable for several special fields. Please consult your tutor.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
227-0377-10L | Physics of Failure and Reliability of Electronic Devices and Systems | W | 3 credits | 2V | I. Shorubalko, M. Held

Abstract
Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective
Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content
Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Lecture notes
Comprehensive copy of transparencies

Literature

363-0790-00L Technology Entrepreneurship

Abstract
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

Objective
This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.
Content

Weekly sessions - recorded.
10+ sessions carried out by guest lecturers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...). Final session: multiple choice semester assignment (100% of grade).

Typical lecture format (2h):
15': Introduction
60': Guest testimonial
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Lecture notes
Lecture slides and case material

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered
Personal Competencies
Critical Thinking assessed

151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

W 4 credits 3G A. Kunz

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems. The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

Lecture notes
The handout is available in German and English.

Prerequisites / notice
Prerequisites:
“Visualization, Simulation and Interaction - Virtual Reality I” is recommended, but not mandatory.

Didactical concept:
The course consists of lectures and exercises.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

Internship in Industry

Number Title Type ECTS Hours Lecturers
227-1550-00L Internship in Industry Z 0 credits external organisers

Abstract
The main objective of the 12-week internship (full-time) is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

Objective
siehe oben

Semester Projects

Number Title Type ECTS Hours Lecturers
227-1101-00L How to Write Scientific Texts E- 0 credits U. Koch

Abstract
This four-hour course covers the basics of writing and presenting scientific work. The focus lies on the structure and the main elements of a scientific text. Formatting guidelines, citation rules, good practice of scientific writing and hints to convince the audience are part of the course.

Objective
- You can write scientific texts using the correct structure
- You can convincingly present scientific work
- You can differentiate the scientific style from novels and news
- You can adhere to citation rules and scientific integrity

Content
The block course covers the following topics:
- Structure of Scientific Texts
- Structure of Scientific Presentations
- Formatting of Scientific Elements (figures, equations, tables)
- Citation Rules and Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
Scientific Integrity, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
You should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.
Semester Project (Nr 1)
Registration in myStudies required!
Supervisor must be a professor at D-ITET or associated, see https://ee.ethz.ch/studies/master-s-programmes/main-master/projects-and-master-thesis.html
The first semester project is compulsory both for students enrolled in the MSc EEIT under the 2008 regulations and for students enrolled under the 2018 regulations.

Abstract
Semester projects are designed to train the students for independent scientific work. A project uses the student's technical and social skills acquired during the master's program. The semester project comprises 280 hours of work and is supervised by a professor.

Objective
see above

Prerequisites / notice
Supervisor must be a professor at D-ITET or associated, see https://www.ee.ethz.ch/studies/main-master/projects-and-master-thesis.html

Semester Project (Nr 2)
Registration in myStudies required!
Supervisor must be a professor at D-ITET or associated, see https://ee.ethz.ch/studies/master-s-programmes/main-master/projects-and-master-thesis.html
The second semester project is compulsory for students enrolled in the MSc EEIT under the 2008 regulations, it is optional for students enrolled under the 2018 regulations.

Abstract
Semester projects are designed to train the students for independent scientific work. A project uses the student's technical and social skills acquired during the master's program. The semester project comprises 280 hours of work and is supervised by a professor.

Objective
see above

Prerequisites / notice
Supervisor must be a professor at D-ITET or associated, see https://www.ee.ethz.ch/studies/main-master/projects-and-master-thesis.html

Science in Perspective
Only courses offered under "GESS Science in Perspective" count in this category. See "Offered in" tab in course view. For more information, please refer to https://gess.ethz.ch/en/studies/science-in-perspective/SiP-FAQs.html
see Science in Perspective: Language Courses ETH/UZH
see Science in Perspective: Type A: Enhancement of Reflection Capability
Recommended Science in Perspective (Type B) for D-ITET

Master's Thesis
Number Title Type ECTS Hours Lecturers
227-1101-00L How to Write Scientific Texts E- 0 credits U. Koch

Abstract
This four-hour course covers the basics of writing and presenting scientific work. The focus lies on the structure and the main elements of a scientific text. Formatting guidelines, citation rules, good practice of scientific writing and hints to convince the audience are part of the course.

Objective
- You can write scientific texts using the correct structure
- You can convincingly present scientific work
- You can differentiate the scientific style from novels and news
- You can adhere to citation rules and scientific integrity

Content
The block course covers the following topics:
- Structure of Scientific Texts
- Structure of Scientific Presentations
- Formatting of Scientific Elements (figures, equations, tables)
- Citation Rules and Scientific Integrity

Literature
Scientific Integrity, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
You should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

Competencies
Subject-specific Competencies
Method-specific Competencies
Social Competencies
Personal Competencies

Concepts and Theories
Media and Digital Technologies
Communication
Critical Thinking
Self-awareness and Self-reflection

assessed
fostered
fostered
assessed
fostered

227-1501-00L Master's Thesis O 30 credits 68D Supervisors
Admission only if ALL of the following apply:

a) bachelor program successfully completed
b) (if applicable) acquired all credits from additional requirements for admission to msc program
c) (2018 regulations): acquired the minimum number of credits in the 'core courses' category
d) successfully completed the semester project(s)

Registration in mystudies required!
Supervisor must be a professor at D-ITET or associated, see https://ee.ethz.ch/studies/master-

Abstract
The Master Program finishes with a 6-months Master Thesis which is directed by a Professor of the Department or a Professor of another Department who is associated with the D-ITET. Students gain the ability to conduct independent scientific research on a specific research problem.

Objective
see above

Prerequisites / notice
Supervisor must be a professor at D-ITET or associated, see https://www.ee.ethz.ch/studies/main-master/projects-and-master-thesis.html

### Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0919-00L</td>
<td>Knowledge-Based Image Interpretation</td>
<td>Z</td>
<td>0</td>
<td>2S</td>
<td>E. Konukoglu, F. Yu</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>With the lecture series on special topics of Knowledge based image interpretation we sporadically offer special talks.</td>
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<td>Objective</td>
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<td></td>
<td>To become acquainted with selected, recent results in image analysis and interpretation.</td>
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<tr>
<td>227-0955-00L</td>
<td>Seminar in Electromagnetics, Photonics and Terahertz</td>
<td>Z</td>
<td>3</td>
<td>2S</td>
<td>J. Leuthold</td>
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<td>Abstract</td>
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<td></td>
<td>Selected topics of the current research activities at the IEF and closely related institutions are discussed.</td>
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<td>Objective</td>
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<td>Have an overview on the research activities of the IEF institute.</td>
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<tr>
<td>227-0980-00L</td>
<td>Seminar on Biomedical Magnetic Resonance</td>
<td>Z</td>
<td>0</td>
<td>1S</td>
<td>K. P. Prüssmann, S. Kozerke, M. Weiger Senften</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>Current developments and problems of magnetic resonance imaging (MRI)</td>
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<td>Objective</td>
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<td></td>
<td>Getting insight into advanced topics in magnetic resonance imaging</td>
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<tr>
<td>401-5680-00L</td>
<td>Foundations of Data Science Seminar</td>
<td>Z</td>
<td>0</td>
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<td>A. Bandeira, H. Bölcskei, J. Peters, F. Yang</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Research colloquium</td>
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</tbody>
</table>

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-AAL</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>E-</td>
<td>6</td>
<td>8R</td>
<td>H.-A. Loeliger</td>
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<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td>Abstract</td>
<td>The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.</td>
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<tr>
<td>Objective</td>
<td>The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust &quot;inversion&quot; of a linear filter.</td>
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<tr>
<td>Content</td>
<td>1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.</td>
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<td>2. The discrete Fourier transform and its use for digital filtering.</td>
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<td></td>
<td>3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture Notes.</td>
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<tr>
<td>227-0103-AAL</td>
<td>Control Systems</td>
<td>E-</td>
<td>6</td>
<td>8R</td>
<td>F. Dörfler</td>
</tr>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td>Abstract</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<tr>
<td>Objective</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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</tbody>
</table>
Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information Technology field. Discussion of the field equations relevant for high voltage engineering.

Lecture Slides

High Voltage Engineering

This course provides a foundation in analog integrated circuit design based on CMOS technologies. Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Further they know the different insulation systems and their dimensioning in practice. They have the ability to identify weak spots in insulation systems and to name possibilities for improvement. Their knowledge is applied to the dimensioning of high-voltage equipment. Methods of computer-modeling in use today are presented and explained.

MATLAB is used for system analysis and simulation.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

MATLAB is used for system analysis and simulation.

Enrolment ONLY for MSC students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

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Enrolment ONLY for MSC students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

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Enrolment ONLY for MSC students with a decree declaring this course unit as an additional admission requirement.
### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

---

### Electrical Engineering and Information Technology Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
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</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

- European Credit Transfer and Accumulation System
  - Special students and auditors need special permission from the lecturers.

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### Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>367-0020-00L</td>
<td>Business Model Innovation for Social Impact</td>
<td>O</td>
<td>7.5 credits</td>
<td>4G</td>
<td>S. Brusoni</td>
</tr>
<tr>
<td>367-0021-00L</td>
<td>Global Business</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>F. Schimmelfennig</td>
</tr>
</tbody>
</table>

**Key for Hours**

V | lecture
G | lecture with exercise
U | exercise
S | seminar
K | colloquium

P | practical/laboratory course
A | independent project
D | diploma thesis
R | revision course / private study

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
**Energy Science and Technology Master**

► Core Courses

At least two core courses must be passed in each area.
All students must participate in the course offered in the area "Interdisciplinary Energy Management"

►► Electrical Power Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1635-00L</td>
<td>Electric Circuits</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Shchetinin</td>
</tr>
<tr>
<td></td>
<td>Students without a background in Electrical Engineering must take &quot;Electric Circuits&quot; before taking &quot;Introduction to Electric Power Transmission: System &amp; Technology&quot;</td>
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<tr>
<td>Abstract</td>
<td>Introduction to analysis methods and network theorems to describe operation of electric circuits. Theoretical foundations are essential for the analysis of the electric power transmission and distribution grids as well as many modern technological devices – consumer electronics, control systems, computers and communications.</td>
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<tr>
<td>Objective</td>
<td>At the end of this course, the student will be able to: understand variables in electric circuits, evaluate possible approaches and analyze simple electric circuits with RLC elements at steady state and during transients, apply circuit theorems to simple meshed circuits, analyze AC circuits and understand the connection of the explained principles to the modelling of 3-phase electric power systems.</td>
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<tr>
<td>Content</td>
<td>Course will introduce electric circuits variables, circuit elements (resistive, inductive, capacitive), resistive circuits and theorems (Kirchhoff's laws, Norton and Thévenin equivalents), nodal and mesh analysis, superposition principle; it will continue by discussing the complete response of RL, RC and RLC circuits during transients, sinusoidal analysis – AC steady state (complex power, reactive, active power) and conclude with the introduction to 3-phase analysis; Mathematical foundations of the circuit analysis, such as matrix operations and complex numbers will be briefly reviewed. This course is targeting students who have no prior background in electrical engineering.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This course is primarily intended for students outside of D-ITET. No prior course in electrical engineering is required.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
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<td></td>
<td>Concepts and Theories assessed</td>
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<td></td>
<td>Techniques and Technologies assessed</td>
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<td>Method-specific Competencies</td>
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<td></td>
<td>Analytical Competencies fostered</td>
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<td></td>
<td>Problem-solving fostered</td>
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<td>Social Competencies</td>
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<td></td>
<td>Communication fostered</td>
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<td></td>
<td>Cooperation and Teamwork fostered</td>
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<td>Customer Orientation fostered</td>
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<td></td>
<td>Leadership and Responsibility fostered</td>
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<td>Self-presentation and Social Influence fostered</td>
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<td>Sensitivity to Diversity fostered</td>
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<td>Negotiation fostered</td>
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<td></td>
<td>Personal Competencies</td>
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<td></td>
<td>Adaptability and Flexibility fostered</td>
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<td></td>
<td>Creative Thinking fostered</td>
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<td>Critical Thinking fostered</td>
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<td></td>
<td>Integrity and Work Ethics fostered</td>
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<td></td>
<td>Self-awareness and Self-reflection fostered</td>
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<td></td>
<td>Self-direction and Self-management fostered</td>
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</table>

| 227-0122-00L | Introduction to Electric Power Transmission: System & Technology | W | 4 credits | 4G | C. Franck, G. Hug |
| Abstract     | Introduction to theory and technology of electric power transmission systems. |
| Objective    | At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of lines, know about electrical safety, calculate electric withstand strength of gas gaps, stationary power flows and other basic parameters in simple power systems. |
| Content      | Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principle of electric power systems. |
| Lecture notes | Lecture script in English, exercises and sample solutions. |
| Competencies | Subject-specific Competencies |
|              | Concepts and Theories assessed |
|              | Techniques and Technologies assessed |
|              | Method-specific Competencies |
|              | Analytical Competencies fostered |
|              | Decision-making fostered |
|              | Media and Digital Technologies fostered |
|              | Problem-solving fostered |
|              | Project Management fostered |
|              | Social Competencies |
|              | Communication fostered |
|              | Cooperation and Teamwork fostered |
|              | Customer Orientation fostered |
|              | Leadership and Responsibility fostered |
|              | Self-presentation and Social Influence fostered |
|              | Sensitivity to Diversity fostered |
|              | Negotiation fostered |
|              | Personal Competencies |
|              | Adaptability and Flexibility fostered |
|              | Creative Thinking fostered |
|              | Critical Thinking fostered |
|              | Integrity and Work Ethics fostered |
|              | Self-awareness and Self-reflection fostered |
|              | Self-direction and Self-management fostered |

| 227-0526-00L | Power System Analysis | W | 6 credits | 4G | G. Hug |
| Abstract     | The goal of this course is understanding the stationary dependencies in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks. |
| Objective    | The goal of this course is understanding the stationary dependencies in electrical power systems and the application of analysis tools in normal but also in faulty state. |
| Content      | The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis and symmetrical components are discussed as well as power flow computation techniques for distribution grids and state estimation. |
| Lecture notes | Lecture notes. |

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Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Media and Digital Technologies fostered
Problem-solving assessed

Personal Competencies

Critical Thinking fostered

227-0117-00L High Voltage Engineering W 6 credits 4G C. Franck, U. Straumann

Abstract
High electric fields are used in numerous technological and industrial applications such as electric power transmission and distribution, X-ray devices, DNA sequencers, flue gas cleaning, power electronics, lasers, particle accelerators, copying machines, .... High Voltage Engineering is the art of gaining technological control of high electrical field strengths and high voltages.

Objective
The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify of weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

Content
- discussion of the field equations relevant for high voltage engineering,
- analytical and numerical solutions/solving of this equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations
- introduction to kinetic gas theory
- mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems
- methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations
- application of the expertise on high voltage components
- excursions to manufacturers of high voltage components

Lecture notes
Lecture Slides

Literature

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies

Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

>>>> Energy Flows and Processes

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>151-1633-00L</td>
<td>Energy Conversion</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>I. Karlin, G. Sansavini, S. A. Hosseini</td>
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</table>

Abstract
This course is intended for students outside of D-MAVT.

Objective
Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course is to give a compact introduction into basics of Thermodynamics: Thermodynamic states and thermodynamic processes; Work and Heat; First and Second Laws of Thermodynamics. Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to building up students intuition about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibrium. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included.

Content
1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximul work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

Lecture notes
Lecture slides and supplementary documentation will be available online.

Literature

This course is intended for students outside of D-MAVT.

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.
### Renewable Energy Technologies

**151-0209-00L**

**Abstract**
The first part of the course covers the engineering aspects of the prominent renewable energy technologies: solar (PV and thermal), wind, hydro, geothermal and bioenergy. We further discuss energy storage, renewable transport and renewable heating & cooling. Finally, we introduce the key concepts of the economics of renewable energy and its integration in the energy system.

**Objective**
Lecture Notes containing copies of the presented slides.

**Prerequisites / notice**
Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

### Subject-specific Competencies

<table>
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<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
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### Content
- Reaction kinetics, fuel oxidation mechanisms, premixed and diffusion laminar flames, two-phase-flows, turbulence and turbulent combustion, pollutant formation, development of sustainable combustion technologies for power generation, shipping and aviation. 

### Literature

### Energy Economics and Policy

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
363-0503-00L | Principles of Microeconomics | W | 3 credits | 2G | M. Filippini

**Abstract**
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

**Objective**
The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Competencies

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<th>Competencies</th>
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<th>Method-specific Competencies</th>
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<td>Self-direction and Self-management</td>
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Interdisciplinary Energy Management

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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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Abstract
This course will allow the students to get an interdisciplinary overview of the "Energy" topic. It will explore the challenges to build a sustainable energy system for the future. This will be done through the means of case studies that the students have to work on. These case studies will be provided by industry partners.

Objective
The students will understand the different aspects involved in designing solutions for a sustainable future energy system. They will have experience in collaborating in interdisciplinary teams. They will have an understanding on how industry is approaching new solutions.

Lecture notes
Descriptions of case studies.
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Industri Poll Internship

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
227-1650-10L | Internship in Industry | O | 12 credits | | external organisers

Abstract
The main objective of the 12-week internship (full-time) is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

Objective
see above

Semester Project

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
227-1101-00L | How to Write Scientific Texts | E- | 0 credits | | U. Koch

Abstract
This four-hour course covers the basics of writing and presenting scientific work. The focus lies on the structure and the main elements of a scientific text. Formatting guidelines, citation rules, good practice of scientific writing and hints to convince the audience are part of the course.

Objective
- You can write scientific texts using the correct structure
- You can convincingly present scientific work
- You can differentiate the scientific style from novels and news
- You can adhere to citation rules and scientific integrity

Content
The block course covers the following topics:
- Structure of Scientific Texts
- Structure of Scientific Presentations
- Formatting of Scientific Elements (figures, equations, tables)
- Citation Rules and Scientific Integrity

Literature
Scientific Integrity, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
You should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

Competencies
- Subject-specific Competencies: Concepts and Theories (assessed)
- Method-specific Competencies: Media and Digital Technologies (fostered)
- Social Competencies: Communication (fostered)
- Personal Competencies: Critical Thinking (assessed)
- Self-awareness and Self-reflection (fostered)

227-1671-10L | Semester Project | O | 12 credits | 20A | Supervisors

Abstract
The semester project is designed to train the students in solving specific problems from the field of Energy Science & Technology. This project uses the technical and social skills acquired during the master's program. The semester project is advised by a professor and must be approved in advance by the tutor.

Objective
see above

Electives

These courses are particularly recommended, other ETH-courses from the field of Energy Science and Technology at large may be chosen in accordance with your tutor.

Electrical Power Engineering

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
227-0113-00L | Power Electronics | W | 6 credits | 4G | J. Huber

Abstract
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time, single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

Lecture notes
Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites / notice
Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories assessed</th>
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<tbody>
<tr>
<td>Methods specific Competencies</td>
<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
<td>Decision-making fostered</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving assessed</td>
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<tr>
<td>Project Management</td>
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</table>

Social Competencies

| Communication fostered                        | Cooperation and Teamwork fostered |
| Customer Orientation fostered                 | Leadership and Responsibility fostered |
| Self-presentation and Social Influence fostered |
| Sensitivity to Diversity fostered             |
| Negotiation fostered                          |

Personal Competencies

| Adaptability and Flexibility fostered         | Creative Thinking fostered     |
| Critical Thinking fostered                    | Integrity and Work Ethics fostered |
| Self-awareness and Self-reflection fostered    | Self-direction and Self-management fostered |

227-0247-00L Power Electronic Systems I

W 6 credits 4G J. Biela, F. Krismer

Abstract
Basics of the switching behavior, gate drive and snubber circuits of power semiconductors are discussed. Soft-switching and resonant DC/DC converters are analyzed in detail and high frequency loss mechanisms of magnetic components are explained. Space vector modulation of three-phase inverters is introduced and the main power components are designed for typical industry applications.

Objective
Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems. Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.

Content
Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail; the operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.

Lecture notes
Lecture notes and associated exercises including correct answers.

Prerequisites / notice
Prerequisites: Introductory course on power electronics is recommended.

Competencies

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<tr>
<th>Subject-specific Competencies</th>
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<tr>
<td>Methods specific Competencies</td>
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<td>Analytical Competencies</td>
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<td>Personal Competencies</td>
<td>Creative Thinking fostered</td>
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</table>

227-0311-00L Qubits, Electrons, Photons

W 6 credits 3V+2U T. Zambelli

Abstract
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and photons, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mucks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!!).
Content

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM, while corresponding videos of the previous years are available in Moodle !!!

Literature


Supplementary material will be uploaded in Moodle.

Prerequisites / notice

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Competencies

Subject-specific Competencies

- Concepts and Theories
  - assessed
- Techniques and Technologies
  - fostered

Method-specific Competencies

- Analytical Competencies
  - assessed
- Decision-making
  - assessed
- Media and Digital Technologies
  - fostered
- Problem-solving
  - assessed
- Project Management
  - assessed

Social Competencies

- Communication
  - fostered
- Cooperation and Teamwork
  - fostered
- Customer Orientation
  - fostered
- Leadership and Responsibility
  - fostered
- Self-presentation and Social Influence
  - fostered
- Sensitivity to Diversity
  - assessed
- Negotiation
  - fostered

Personal Competencies

- Adaptability and Flexibility
  - assessed
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - assessed
- Self-awareness and Self-reflection
  - assessed
- Self-direction and Self-management
  - assessed

227-0523-00L Railway Systems I W 6 credits 4G M. Meyer

Abstract

Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance

Objective

- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators
Critical Thinking
Concepts and Theories

The goals of this course are:
1. Understanding the fundamentals of the electromagnetic, thermal, mechanical, and coupled field simulations.
2. Performing effective simulations of primary equipment of electric power systems.
3. Using finite element software to solve practical design problems.
4. Learning the theoretical background of the finite element method (FEM) and its application to low- and high-frequency electromagnetic field simulation problems.
5. Understanding and interpreting the obtained results.

The course should be done by using one of the commercially available field simulation software (Infolytica, ANSYS, and / or COMSOL).

Prerequisites / notice

- Knowledge on the worldwide liberalisation of electricity markets, pan-european power trading and the role of power exchanges.
- Understand financial products (derivatives) based on power.
- Management of a portfolio containing physical production, contracts and derivatives.
- Ancillary services, balancing power market, Swiss market model.
- Hedging, options and derivatives, performance indicators for the risk management.
- Modelling of physical assets, cross-border trading.
- Very fast transients in gas insulated switchgears (GIS).
- Electromagnetic analysis of electric machines.
- Nonlinear quasi-electrostatic analysis of surge arresters.
- Dielectric analysis of high-voltage equipment.
- Electromagnetic compatibility (EMC).

Competencies

- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Personal Competencies: Critical Thinking assessed

Lecture notes

- Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice

- Dozent: Dr. Markus Meyer, Emkamatik GmbH

Objective

- The student should learn the fundamentals of the electromagnetic, thermal, mechanical, and coupled field simulations necessary for modern product development and research based on virtual prototyping.
- The student should be able to properly and efficiently use the software to simulate practical design problems and to understand and interpret the obtained results.

Content

1. Electromagnetic Fields and Waves: Simulation Aspects (1 lecture, 2 hours)
   a. Short review of the governing equations
   b. Boundary conditions
   c. Initial conditions
   d. Linear and nonlinear material properties
   e. Coupled fields (electro-mechanical and electro-thermal coupling)

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
   a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
   b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
   c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
   d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
   a. Dielectric analysis of high-voltage equipment
   b. Nonlinear quasi-electrostatic analysis of surge arresters
   c. Eddy-currents analysis of power transformers
   d. Electromagnetic analysis of electric machines
   e. Very fast transients in gas insulated switchgears (GIS)
   f. Electromagnetic compatibility (EMC)
## Content

1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX

2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions

3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   2.8. Risk Management 3 (enterprise wide)

4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

## Lecture notes

Handouts of the lecture

## Prerequisites / notice

Case studies and ML exercise for Power Market can give bonus points for the exam. Guest speakers for specific topics.

## Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Decision-making</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Media and Digital Technologies</td>
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<td>Creative Thinking</td>
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<td>Project Management</td>
<td>Critical Thinking</td>
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<td>assessed</td>
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## Simulation of Photovoltaic Devices - From Materials to Modules

### 227-0615-00L

- **W**
- **3 credits**
- **U. Aeberhard**

### Abstract

The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules.

### Objective

Get an overview of the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to analyze, optimize, and predict the performance of solar cells and modules.

### Content

- Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency water-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture)

### Literature

- M. A. Green, „Solar cells: operating principles, technology, and system applications“, Prentice Hall, 1982.

### Prerequisites / notice

Undergraduate physics (including basic quantum mechanics), mathematics, semiconductor devices, optics. Knowledge of some scripting language (e.g. python) is of advantage.
## Competencies

### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

### Personal Competencies
- Adaptability and Flexibility: fostered
- Critical Thinking: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

## Content

**Abstract**
Physics, technology, characteristics and applications of photovoltaic solar cells and systems.

**Objective**
The students will appreciate the potential of solar radiation and photovoltaics, will learn the physics and technology of various solar cells, and will get to know the design basics of PV modules and systems for different applications.

**Content**
Introduction to photovoltaics and economic aspects, solar radiation, semiconductor physics and operation of solar cells, technology of wafer-based (Si, GaAs, multi-junction) and thin-film (CIGS, CdTe, perovskite) solar cells, emerging technologies, design of PV modules, systems and plants including system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples such concentrated photovoltaics and power generation for space applications.

**Lecture notes**
Lecture slides (PDF files in English) will be available on Moodle and lecture recordings will be available on the ETH video portal.

**Prerequisites / notice**
Prerequisites: Basic knowledge of semiconductors.

### Energy Flows and Processes

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0123-00L</td>
<td>Experimental Methods for Engineers</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>D. J. Norris, F. Coletti, M. Lukatskaya, A. Manera, O. Supponen, M. Tibbitt</td>
</tr>
</tbody>
</table>

**Abstract**
The course presents an overview of measurement tasks in engineering environments. Different concepts for the acquisition and processing of typical measurement quantities are introduced. Following an initial in-class introduction, laboratory exercises from different application areas (especially in thermofluidics, energy, and process engineering) are attended by students in small groups.

**Objective**
Introduction to various aspects of measurement techniques, with particular emphasis on thermo-fluidic, energy, and process-engineering applications.

Understanding of various sensing technologies and analysis procedures.

Exposure to typical experiments, diagnostics hardware, data acquisition, and processing.

Study of applications in the laboratory. Fundamentals of scientific documentation and reporting.

In-class introduction to representative measurement techniques in the research areas of the participating institutes (fluid dynamics, energy technology, and process engineering).

Student participation in ~6 laboratory experiments (study groups of ~3 students, dependent on the number of course participants and available experiments).

**Lecture notes**
Lab reports for all attended experiments have to be submitted by the study groups.

**Literature**

**Prerequisites / notice**
Basic understanding in the following areas:
- fluid mechanics, thermodynamics, heat and mass transfer
- electrical engineering / electronics
- numerical data analysis and processing (e.g. using MATLAB)

**Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered
- Communication: fostered
- Cooperation and Teamwork: fostered
- Leadership and Responsibility: fostered
- Critical Thinking: fostered
- Self-direction and Self-management: fostered
Nuclear Energy Conversion 151-0163-00L

Abstract
Physical fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding.

Objective
Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.

Content
Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of reactor technology.

Lecture notes
Hand-outs will be distributed. Additional literature and information on the website of the lab: https://www.ethz.ch/content/specialinterest/mavt/energy-technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00-nuclear-energy-conversion.html

Literature

R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

Wind Energy 151-0216-00L

Abstract
The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy. These subjects are introduced through a discussion of the basic principles of wind energy generation and conversion, and a detailed description of the broad range of relevant technical, economic and environmental topics.

Objective
The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy.

Content
This mechanical engineering course focuses on the technical aspects of wind turbines; non-technical issues are not within the scope of this technically oriented course. On completion of this course, the student shall be able to conduct the preliminary aerodynamic and structural design of the wind turbine blades. The student shall also be more aware of the broad context of drivetrains, dynamics and control, electrical systems, and meteorology, relevant to all types of wind turbines.

Introduction to Modeling and Optimization of Sustainable Energy Systems 151-0221-00L

Abstract
This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.

Objective
At the end of this course, students will be able to:
- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

In the course "Introduction to Modeling and Optimization of Sustainable Energy Systems", the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

Content
The global energy transition: Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.

Lecture notes
Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

Energy Systems Analysis: an Introduction and Overview with Applications 151-0245-00L

Abstract
Introductory (advanced Bachelor or beginner Master level) course on Energy Systems Analysis, providing an overview of the field and methods. After an introduction to systems thinking and characterisation of technologies, three main blocks cover with Lifecycle Assessment (LCA, 3 units), bottom-up linear optimisation models (5 units) and Multi-Criteria Decision Analysis (MCDATA, 3 units).

Objective
- Analyse energy technologies with respect to different criteria/characteristics.
- Discuss and debate the pros and cons of different ESA models/approaches (for specific applications)
- Explain the system-level interdependencies/interconnections within the energy system
- Evaluate the effect of uncertainties and "the human dimension" on ESA and scenarios

Content
The course provides an introduction and overview to the most well-established models and methods of energy systems analysis, in each case introducing students to the theory and assumptions of the method, strengths and weaknesses of the specific approach, and case studies for exemplary energy technologies and systems. The students are taught to understand and will be able to apply the basic principles of these methods in the context of targeted assignments relating to real-world energy systems.

Lecture notes
No but slides are provided before the lectures and videos recorded.

Literature
Prerequisites / notice
Will be provided during the course.

No specific prerequisites, some background in energy-related topics in the Bachelor would be beneficial.

Competencies
Subject-specific Competencies
Concepts and Theories
assessed
Techniques and Technologies
fostered
Method-specific Competencies
Analytical Competencies
assessed
Decision-making
assessed
Problem-solving
assessed
Social Competencies
Communication
fostered
Cooperation and Teamwork
fostered
Sensitivity to Diversity
fostered
Personal Competencies
Negotiation
fostered
Adaptability and Flexibility
fostered
Creative Thinking
fostered
Critical Thinking
assessed
Integrity and Work Ethics
fostered
Self-awareness and Self-reflection
fostered
Self-direction and Self-management
fostered

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### 151-0251-00L Principles, Efficiency Optimization and Future Applications of IC Engines

**Abstract**

**Objective**
The students get familiar with operating characteristics and efficiency maximization methods of IC engines for propulsion and decentralized electricity (and heat) generation. To this end, they learn about simulation methods and related experimental techniques for performance assessment in a combination of lectures and exercises.

**Content**
This lecture aims at introducing the students to the working principles and efficiency optimization methods for Internal Combustion (IC) engines which are expected to continue to play a very important role in transportation (long-haul heavy duty, marine) and decentralized combined heat and power generation. Following an overview of different applications and powertrains, the course will focus on the following topics: First, a generic overview of the history of IC-Engines is given, and the basic dimensions and specific engine-relevant terminology are introduced. Next, operating maps for different duty cycles are discussed, highlighting the benefits of individual powertrain configurations for different usage scenarios. The high-pressure thermodynamic process and combustion-induced heat release are analyzed in detail and the design of the combustion processes is discussed in view of further optimization of the energy conversion efficiency. The concept of boosting, its challenges and potential are also presented. In addition, flow field characteristics, convective and radiative heat transfer and combustion modes (Otto, Diesel and “multi-mode” cycles) will be discussed along with possible simulation methods. The course consists of lectures combined with exercises. In addition, several invited guest talks will be held by representatives from Swiss industrial companies active in this field. Provided the pandemic measures allow, visits to different engine test facilities are further envisioned.

**Literature**

**Prerequisites / notice**
This course provides background for the course 151-0254-00L “Environmental Aspects of Future Mobility” held in the Spring Semester, where the focus is on emission formation and minimization, exhaust gas after treatment systems and potentials of future synthetic/e-fuels in IC engines; all given in the broader context of a future mobility/transportation options (battery electric, hybrids, fuel cells etc.) and transformation pathways towards sustainability.

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed

### 151-0567-00L Engine Systems

**Abstract**
Introduction to current and future engine systems and their control systems.

**Objective**
Introduction to methods of control and optimization of dynamic systems. Application to real engines. Understand the structure and behavior of drive train systems and their quantitative descriptions.

**Content**
Physical description and mathematical models of components and subsystems (mixture formation, load control, supercharging, emissions, drive train components, etc.). Case studies of model-based optimal design and control of engine systems with the goal of minimizing fuel consumption and emissions.

**Lecture notes**
Introduction to Modeling and Control of Internal Combustion Engine Systems
Guzzella Lino, Onder Christopher H.
ISBN: 978-3-642-10774-0

**Prerequisites / notice**
Combined homework and testbench exercise (air-to-fuel-ratio control or idle-speed control) in groups

### 151-0569-00L Vehicle Propulsion Systems

**Abstract**
Introduction to current and future propulsion systems and the electronic control of their longitudinal behavior.

**Objective**
Introduction to methods of system optimization and controller design for vehicles. Understanding the structure and working principles of conventional and new propulsion systems. Quantitative descriptions of propulsion systems.

**Content**
Understanding of physical phenomena and mathematical models of components and subsystems (manifold, automatic and continuously variable transmissions, energy storage systems, electric drive trains, batteries, hybrid systems, fuel cells, road/wheel interaction, automatic braking systems, etc.). Presentation of mathematical methods, CAE tools and case studies for the model-based design and control of propulsion systems with the goal of minimizing fuel consumption and emissions.

**Lecture notes**
Vehicle Propulsion Systems.
Introduction to Modeling and Optimization
Guzzella Lino, Sciarretta Antonio
ISBN: 978-3-642-35912-5

**Prerequisites / notice**
Lectures of Prof. Dr. Ch. Onder and Dr. Ph. Elbert are also possible to be held in German.

### 529-0613-01L Process Simulation and Flowsheeting

**Abstract**
This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies. Commercial software packages (Aspen) are introduced for solving process flowsheeting and optimization problems.

**Objective**
This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the model-relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

**Prerequisites / notice**
This course will be held in the Autumn Semester 2024.

**Literature**
3. Guzzella Lino, Onder Christopher H., Engine Systems
4. Wright, Vehicle Propulsion Systems

**Prerequisites / notice**
This course provides the necessary background for the course 151-0254-00L “Environmental Aspects of Future Mobility” held in the Spring Semester.
Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process flowsheeting:
- Flowsheet partitioning and tearing
- Solution methods for process flowsheeting
- Simultaneous methods
- Sequential methods

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
- Non-linear programming, NLP
- Mixed-integer linear programming, MILP
- Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimisation & debugging

Literature
An exemplary literature list is provided below:
- Smith, R. Chemical process design and integration, Wiley (2005).

Prerequisites / notice
A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

Energy Economics and Policy

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>101-0577-00L</td>
<td>An Introduction to Sustainable Development in the Built Environment</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>G. Habert, E. Zea Escamilla</td>
</tr>
</tbody>
</table>

Abstract
In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. This decarbonization strategy is additional to Sustainable Development goals formulated the same year by the UN general assembly.

What does that mean for the built environment?
This course provides an introduction to the notion of sustainable development when applied to our built environment.

Objective
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.
The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development and beyond

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification
- Method 4: Material Flow Analysis

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world

- Synthesis: Transition to sustainable development

Lecture notes
All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Problem-solving: assessed

Social Competencies
- Self-presentation and Social Influence: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Critical Thinking: assessed
- Self-awareness and Self-reflection: fostered

102-0317-00L Advanced Environmental Assessments
Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0317-00 Advanced Environmental Assessments (3KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).

Abstract
This course deepens students' knowledge of the environmental assessment methodologies and their various applications.

Objective
This course has the aim of deepening students' knowledge of the environmental assessment methodologies and their various applications. In particular, students completing the course should have the
- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

Content
- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

Lecture notes
No script. Lecture slides and literature will be made available on Moodle.

Literature
Literature will be made available on Moodle.

Prerequisites / notice
Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered

Personal Competencies
- Critical Thinking: assessed

102-0317-03L Advanced Environmental Assessment (Computer Lab I)
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice.

Objective
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed

Personal Competencies
- Critical Thinking: assessed

102-0317-04L Advanced Environmental Assessment (Computer Lab II)
Not for master students in Environmental Engineering choosing module Ecological System Design as already included in Environment and Computer Laboratory I (Year Course): 102-0527-00 and 102-0528-00.
This course teaches approaches and methods to identify, assess and manage environmental (mainly) and societal (to some extent)

Critical Thinking

W

assessed

Communication

assessed

assessed

Social Competencies

assessed

Cooperation and Teamwork

assessed

fostered

Personal Competencies

assessed

Critical Thinking

assessed

fostered

Self-awareness and Self-reflection

fostered

102-0327-01L Implementation of Environmental and Other Sustainability Goals

Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0327-01 Advanced Environmental Assessments (2KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).

Abstract

This course teaches approaches and methods to identify, assess and manage environmental (mainly) and societal (to some extent) aspects in organisations. The course contains an introduction to the global ISO 14001 standard on environmental management, into the concept of ecobalance of organisations, and supply chain management, and a general view on how such approaches fit into a management system.

Objective

Students will learn to

- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including ‘organisational LCA’ (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- apply life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000), especially into strategy development, planning, controlling and communication;
- The concept of ‘continuous Improvement’, and its application to environmental management
- Life Cycle Costing, as part of Life Cycle Management
- environmental performance measurement of an organisation, including ‘organisational LCA’ (Ecobalance), incl. practical examples of companies
- single score environmental assessment methods, with a focus on the ‘ecopoints’ method
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small homework excercises to apply the course topics and methods issues.

Lecture notes

Documents will be available on Ilias

Literature

Will be made available.

Prerequisites / notice

This course is meant for any interested student.

(Students of ESD Ecological Systems Design should choose the combined "AESEA" course (102-0307-01), which is specifically offered and mandatory for their module and includes this course.

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic will profit more from this course after reading an appropriate textbook before or at the beginning of this course, e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2).

Competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

assessed

Problem-solving

assessed

Project Management

fostered

Social Competencies

Communication

assessed

Cooperation and Teamwork

fostered

Personal Competencies

Critical Thinking

fostered

Self-awareness and Self-reflection

fostered

363-0537-00L Resource and Environmental Economics

Abstract

Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.
Objective
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental resources and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature

Competencies

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<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Methodspecific Competencies</th>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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363-0387-00L Corporate Sustainability W 3 credits 2G V. Hoffmann, C. Bening-Bach, B. Girod, L. Miehé

Abstract
The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. The module combines asynchronous videos, live sessions, with a group work phase between weeks 5-10 of semester during which students deep-dive into one of 10 sustainability challenges.

Objective
Students
- assess the limits and the potential of corporate sustainability for sustainable development
- develop competencies that are useful in the context of corporate sustainability and beyond (analytical competency, critical thinking, problem solving)
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams

Content
Corporate Sustainability is the flagship course of the Group for Sustainability and Technology at D- MTEC. In this course, students learn about key concepts in corporate sustainability and develop skills to implement them in the real world. The course prepares students for making well-informed sustainability decisions in their future careers.

The course uses constructive alignment to bring the various innovative teaching and learning elements (e.g., case-based experiential learning, reflective thinking and blended learning with videos and quizzes) into a coherent transformational journey. Students can now flexibly, efficiently, and effectively acquire the conceptual foundations that are essential for a substantial understanding of corporate sustainability,

For part of the course, students work in groups to complete a set of graded assignments designed to guide them into a deep dive on a selected corporate sustainability challenge. Please note that full participation in this part is essential, so make sure you are available. Furthermore, these group assignments count towards the overall grade for the course.

For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Lecture notes
Presentation slides will be made available on Moodle after lectures.

Literature
Literature recommendations will be distributed via Moodle, and are available from the start of the course.

Prerequisites / notice
TEACHING FORMAT/ ATTENDANCE: The course includes several mandatory sessions that participants must attend to successfully earn credit points. It is not possible to take the class purely online.

Competencies

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<th>Competencies</th>
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<th>Method-specific Competencies</th>
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</table>

Social Competencies
Communication
- fostered

Cooperation and Teamwork
- fostered

Negotiation
- fostered

Personal Competencies
Creative Thinking
- fostered

Critical Thinking
- assessed

Self-awareness and Self-reflection
- fostered

Science in Perspective
Only courses offered under “GESS Science in Perspective” count in this category. See “Offered in” tab in course view. For more information, please refer to https://gess.ethz.ch/en/studies/science-in-perspective/SIP-FAQs.html

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflective Capabilities

Recommended Science in Perspective (Type B) for D-ITET

Master’s Thesis

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1099 of 2667
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0 credits</td>
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<td>U. Koch</td>
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</tbody>
</table>

**Abstract**

This four-hour course covers the basics of writing and presenting scientific work. The focus lies on the structure and the main elements of a scientific text. Formatting guidelines, citation rules, good practice of scientific writing and hints to convince the audience are part of the course.

**Objective**

- You can write scientific texts using the correct structure
- You can convincingly present scientific work
- You can differentiate the scientific style from novels and news
- You can adhere to citation rules and scientific integrity

**Content**

The block course covers the following topics:
- Structure of Scientific Texts
- Structure of Scientific Presentations
- Formatting of Scientific Elements (figures, equations, tables)
- Citation Rules and Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

**Literature**

Scientific Integrity, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

**Prerequisites / notice**

You should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

**Competencies**

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<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Self-awareness and Self-reflection</td>
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**227-1601-00L Master's Thesis**

Only students who fulfill the following criteria are allowed to enroll for and start with their master thesis:
- a. successful completion of the bachelor program;
- b. any additional requirements necessary to gain admission to the master program EST have been successfully completed;
- c. both the semester project and the internship have been successfully completed.

**Registration in mystudies required!**

**Abstract**

The master program in Energy Science and Technology culminates in a six months research project which addresses a scientific research question on one's chosen area of specialization. The masters thesis is supervised by a program-affiliated faculty member and the topic must be approved in advance by the tutor.

**Objective**

see above

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**Energy Science and Technology Master - Key for Type**

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
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<td>W</td>
<td>Eligible for credits</td>
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<table>
<thead>
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<th>Key</th>
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<tbody>
<tr>
<td>O</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>W</td>
<td>Courses outside the curriculum</td>
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<td>Z</td>
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</table>

| P   | practical/laboratory course |
| A   | independent project         |
| D   | diploma thesis              |
| R   | revision course / private study |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Mathematics I

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
   Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
   Elementary particles and atoms. Electron configuration of the elements. Periodic system.
4. Basics of chemical thermodynamics
   System and surroundings. Description of state and change of state of chemical systems.
5. First law of thermodynamics
6. Second law of thermodynamics
   Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. Gibbs energy and chemical potential.
8. Chemical equilibrium
   Law of mass action. Reaction quotient and equilibrium constant. Phase transition equilibrium.
9. Acids and bases
10. Dissolution and precipitation.
    Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes
Online-Skript mit durchgerechneten Beispielen.

Literature
Weiterführende Literatur:
Dynamic Earth I

**Abstract**
Provides a basic introduction into Earth Sciences, emphasizing different rock-types and the geological rock-cycle, as well as introduction into geophysics, plate tectonics and planetology.

**Objective**
Understanding basic geological and geophysical processes

**Content**
Overview of the Earth as a system, with emphasis on plate tectonic theory and the geological rock-cycle. Provides a basic introduction to crystals and minerals and different rock-types. Lectures include processes in the Earth's interior, physics of the earth, planetology, introduction to magmatic, metamorphic and sedimentary rocks. Exercises are conducted in small groups to provide more in depth understanding of concepts and content of the lectures.

**Literature**
https://doi.org/10.1007/978-3-662-48342-8

**Prerequisites / notice**
Exercises and short excursions in small groups (10-15 students) will be lead by student assistants. Specific topics in earth sciences will be discussed using examples and case studies. Hand samples of the major rock types will be described and interpreted. Short excursions in the region of Zurich will permit direct experience with earth science processes (e.g. earth surface processes) and recognition of earth science problems and solutions relevant for modern society (e.g. building materials, water resources). Working in small groups will allow for discussion and examination of actual earth science themes.

### First Year Additional Compulsory Courses

<table>
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<tr>
<th>Number</th>
<th>529-0030-00L</th>
<th>Laboratory Course: Elementary Chemical Techniques</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>3</td>
<td>4P</td>
<td>A. de Mello, F. Jenny, N. Kobert, M. H. Schroth</td>
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</table>

**Abstract**
This practical course provides an introduction to elementary laboratory techniques. The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g. investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.

**Objective**
This course is intended to provide an overview of experimental chemical methods. The handling of chemicals and proper laboratory techniques represent the main learning targets. Furthermore, the description and recording of laboratory processes is an essential part of this course.

**Content**
The classification and analysis of natural and artificial compounds is a key subject of this course. It provides an introduction to elementary laboratory techniques, and the experiments cover a wide range of analytic and synthetic tasks: Selected samples (e.g. soil and water) will be analysed with various methods, such as titrations, spectroscopy or ion chromatography. The chemistry of aqueous solutions (acid-base equilibria and solvation or precipitation processes) is studied. The synthesis of simple inorganic complexes or organic molecules is practised. Furthermore, the preparation and handling of environmentally relevant gaseous species like carbon dioxide or nitrogen oxides is a central subject of the Practikum.

**Lecture notes**
The instructions to the experiments will be published on Moodle.

**Literature**
A thorough study of all script materials is requested before the course starts.

**Competencies**

*Subject-specific Competencies*
- Concepts and Theories
- Techniques and Technologies

*Social Competencies*
- Cooperation and Teamwork

### Basic Courses II

### Core Courses

<table>
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<tr>
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<th>402-0000-03L</th>
<th>Laboratory Course in Physics for Students in Earth Sciences</th>
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<td></td>
<td>O</td>
<td>2</td>
<td>4P</td>
<td>A. Biland, A. Eggenberger, A. Müller</td>
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</table>

**Abstract**
Please make an enrolment in mystudies. Register the experiments here: https://www.lehrbetrieb.ethz.ch/laborpraktika.
For further information visit: https://ap.phys.ethz.ch

Only students from 3rd Semester BSc Earth Sciences on are admitted to this Laboratory Course.

**Objective**
The central aim is to provide an individual experience of the physical phenomena and the basic principles of the experiment. By conducting simple physical experiments the student will learn how to properly use physical instruments and how to evaluate the results correctly.

**Content**
Laboratory work forms an important part of the education in natural sciences. The overhead topic in this lab course is the confrontation of fundamental problems of any experiment. Using the example of simple tasks, the following aspects should be considered in particular:
- the practical structure of the experiment and the knowledge of the measuring methods
- the use and handling of measuring instruments
- the correct evaluation and assessment of the observations
- deepening the knowledge in some areas of elementary physics
- physics as a personal experience.

**Lecture notes**
Manuals; lab safety; error calculation and report writing; 6 selected experiments on a variety of topics. Selection of experiments may vary between courses.

**Competencies**

*Subject-specific Competencies*
- Concepts and Theories
- Techniques and Technologies

*Method-specific Competencies*
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

*Social Competencies*
- Communication
- Cooperation and Teamwork

*Personal Competencies*
- Critical Thinking
- Integrity and Work Ethics
### Examination Block 1

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<td>Abstract</td>
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<td>Introduction to the way physicists think and work with the help of concept questions, demonstration experiments and problem solving. Wherever possible, applications from thermodynamics, electricity and magnetism are taught from the areas of the degree programmes.</td>
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<td>Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.</td>
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<td>Thermodynamics with first and second law, phase transformations, transport phenomena. Introduction to electricity and magnetism, as well as waves and modern physics.</td>
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<td>Friedhelm Kuypers</td>
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<td>651-3400-00L</td>
<td>Geochemistry I</td>
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<td>M. Schönbächler, D. Vance</td>
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<td></td>
<td>Introduction to geochemistry and its application to the study of the origin and evolution of the Earth and planets.</td>
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<td></td>
<td>Gain an overview of geochemical methods used in various fields of Earth Sciences and how they can be applied to study geological processes in the Earth's mantle, crust, oceans and atmosphere.</td>
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<td>Content</td>
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<td>This course is an introduction into geochemistry with a special focus on the basic concepts used in this rapidly evolving field. The course deals with the geochemist's toolbox: the basic chemical and nuclear properties of elements from the periodic table and how these elements can be used to ask fundamental questions in Earth Sciences. The important concepts used in solid-solution-gas equilibria are introduced. The concepts of chemical reservoirs and geochemical cycles are discussed with examples from the carbon cycle in the Earth. The course also addresses geological applications in low- and high-temperature geochemistry, including the formation of continents, the differentiation of the Earth, the geochemistry of ocean and continental waters.</td>
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<td>Lecture notes</td>
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<td>Prerequisite: chemical thermodynamics, basic inorganic chemistry and physics, basics of Python programming</td>
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<td>Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.</td>
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<td>Objective</td>
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<td>Students are able</td>
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<td></td>
<td>- to explain the physical structure and chemical composition of the atmosphere</td>
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<td>- to quantitatively describe and understand the fundamental physical and chemical process in the atmosphere</td>
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<td>- to explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.</td>
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<td></td>
<td>Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds.</td>
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<td>fostered</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<td>Personal Competencies</td>
<td>Critical Thinking</td>
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<td>Self-awareness and Self-reflection</td>
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### Examination Block 2

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<tr>
<th>Number</th>
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<tr>
<td>701-0071-00L</td>
<td>Mathematics III: Systems Analysis</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>C. Brunner, R. Knutti, H. Wernli</td>
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</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1103 of 2667
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

To understand and describe the basic principles of the hydrologic cycle and water flow in streams and aquifers.

This course provides an introduction to oceanography and hydrogeology, with a special focus on the basic physicochemical concepts that fostered General knowlede of seismology.

To conduct simple calculations of water transfer in streams and aquifers as well as of flood frequencies and magnitudes.

To discuss surface and groundwater as a water resource.

To interpret different ion distributions in aquifers in terms of basic water chemistry, fluid-mineral reactions, water contamination, and water origin.

To understand the major features of ocean basins and the tectonic controls on their structure.

To identify the major controls on the temperature, salinity and density structure of the oceans.

To describe how these controls interact to drive surface and interior ocean circulation.

To interpret different kinds of element distribution in the oceans in terms of basic chemistry, sinks, sources and internal biogeochemical cycling.

To discuss the cycles of carbon and oxygen in the ocean, with a view to the critical analysis of how the oceans respond to, cause and record the dynamics of these cycles in Earth history.

This course provides an introduction to oceanography and hydrogeology, with a special focus on the basic physicochemical concepts that control the properties and behaviour of two major reservoirs of water on Earth.

The hydrogeology component will: 1) describe the hydrologic cycle, with a focus on the importance of groundwater to society; introduce the basic physical aspects of groundwater flow, including Darcy's law, hydraulic head, hydraulic conductivity, aquifers; 2) describe the basics of groundwater chemistry, including major ions and mean meteoric water line, basics of groundwater contamination; 3) introduce the interface with the oceans, including hydrothermal circulation at mid-ocean ridges, ocean-water intrusion into groundwater at coasts.

The oceanography component will: 1) provide an overview of the physical circulation of the oceans, including its importance for heat transfer around the surface of the Earth and for climate; 2) describe the basic processes that control the chemistry of the oceans, including its temporal and spatial variability; 3) introduce some simple concepts in biological oceanography, including the dependence of ocean ecology on nutrient distributions. There will be a specific focus on how the physics, chemistry and biology of the ocean might have changed through Earth history, and the impact of oceanic processes on Earth's climate.

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Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

To understand and describe the basic principles of the hydrologic cycle and water flow in streams and aquifers.

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To conduct simple calculations of water transfer in streams and aquifers as well as of flood frequencies and magnitudes.

To discuss surface and groundwater as a water resource.

To interpret different ion distributions in aquifers in terms of basic water chemistry, fluid-mineral reactions, water contamination, and water origin.

To understand the major features of ocean basins and the tectonic controls on their structure.

To identify the major controls on the temperature, salinity and density structure of the oceans.

To describe how these controls interact to drive surface and interior ocean circulation.

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In the lecture part, the objective of this course is to understand the basic concepts needed to understand the evolution, structure, and dynamics of the Earth from the perspectives of the mineralogy and crystallography. According to the course, we must understand how biological cells and its components are built from essential elements and molecules, how cells function and which life styles organisms developed, where organisms can exist and which factors select for their presence, how biologically usable forms of energy come from, and under which conditions they can be exploited, how biological metabolism can change environmental conditions and composition, which biological products can lead to signals preserved in the rock record, and how biomolecules and elements are altered in sedimentary deposits, how organic and inorganic components are cycled through the biosphere, and how biochemical cycles function, how "biological innovations" evolved and changed in response to environmental changes.

Scientific applications of geobiological knowledge are found in fields like Microbial Ecology, Geochemistry, Palaeontology, Sedimentology, Petrology, Ocean Research, Environmental Sciences, Astrobiology and Archaeology. Practical applications of geobiological knowledge are needed in fields like stabilisation of existing and design of safe waste repositories, surveilling ground water resources, sewage treatment, exploitation of and prospecting for fossil carbon sources, soil remediation, mineral exploration and teaching, forensic science and medicine.

Accordingly, we must understand:
- formation processes of the solar system, the earth, and the moon.
- structure of the earth
- some important experimental approaches to determine the structure of the earth
- some important phase transformations appeared in the Earth's deep interior.
- some important crystal structures appeared in the Earth's deep interior.
- mineralogy of the upper mantle, transition zone, lower mantle, and the core.
- chemical composition of the mantle and core.
- comparison of the mantle and core.

At the end of the exercise course, the students will be able to determine and describe the macroscopically observable properties of about 70 minerals and know the sum formulae of about 50 of them.

At the end of the lecture part, students should be able to explain the following:
- formation processes of the solar system, the earth, and the moon.
- structure of the earth
- some important experimental approaches to determine the structure of the earth
- some important phase transformations appeared in the Earth's deep interior.
- some important crystal structures appeared in the Earth's deep interior.
- mineralogy of the upper mantle, transition zone, lower mantle, and the core.
- chemical composition of the mantle and core.

At the end of the exercise course, the students will be able to determine and describe the macroscopically observable properties of about 70 minerals and know the sum formulae of about 50 of them.
Planet Earth has had a complex history since its formation ~4.6 billion years ago. The surface Earth is often thought of as a set of interacting systems, often with feedbacks between them. These interacting systems control the tectonics, geomorphology, climate, and biology of the surface Earth. To fully understand the nature of the Earth System, including the controls on its past evolution, its present state, and its future, an integrated perspective is required.

The following concepts are introduced in the course:
- Fundamentals of programming
- Analysis of datasets of differing types
- Effective and scientifically correct visualisation
- Statistical description of a dataset

This course combines petrography, geochemistry, experimental and theoretical petrology to assess fundamental igneous and metamorphic processes controlling the generation and evolution of igneous and metamorphic rocks in time and space. Principle targets are (1) the generation of magmas in the Earth mantle and crust, differentiation and emplacement of magmas at depth and on the surface and (2) metamorphism of igneous and sedimentary rock series and their relationships in the framework of global tectonics. The material is mostly presented in qualitative way. A quantification of igneous and metamorphic processes based on modal mineralogy, geochemistry, phase petrology and thermodynamic principles is assessed and further promoted in the accompanying homework and exercises.

Basic knowledge of rock-forming minerals and the classification of igneous and metamorphic rocks are required and will be further trained during the exercises.

The end-of-term examination will take place in the two weeks scheduled in January.
### Methods

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<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>651-3527-00L</td>
<td>Earth Science Mapping Exercises II</td>
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<td>2P</td>
<td>S. Volante</td>
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<td>All participants are able to:</td>
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<td>- Read and understand complex geological maps;</td>
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<td>- Assess, select, and project information from real case studies;</td>
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<td>- Make tectonic overview sketches and construct meaningfull cross-sections;</td>
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<td>Content</td>
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<td>Advanced analysis of geological maps and construction of geological sections. Special points: normal faults of the Rheintal graben, Val de Ruz, Helvetic nappes of the Säntis area. Reconstruction of the geological history of the map areas. References to the Geology of Switzerland.</td>
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<td>Lectures notes</td>
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<td>Requirement: Earth science mapping exercises I</td>
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<th>Number</th>
<th>Mathematics IV: Statistics</th>
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<tr>
<td></td>
<td>Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.</td>
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<td>Capacity to learn from data: good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.</td>
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<td></td>
<td>Content</td>
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<td>Ausführliches Skript zur Vorlesung ist erhältlich.</td>
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<td>Prerequisites / notice</td>
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<td>Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.</td>
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<td>Introduction to the fundamental concepts and data processing capabilities of Geographic Information Systems (GIS). Practical application of geospatial data management and analysis functions based on a selected geoscience project.</td>
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<td>Objective</td>
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<td>Students can</td>
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<td>- explain the basic principles of GIS</td>
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<td>- solve a complex, real-world GIS problem in the field of Earth Science</td>
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<td>- apply the principles of data modelling and geoprocessing with ArcGIS Pro: data design and modelling, data acquisition, data integration of different data types (including LiDAR data), spatial analysis of vector and raster data, special functions for digital terrain modelling and hydrology, map production and 3D visualisation.</td>
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<td></td>
<td>Theoretical introduction to the concepts, spatial data types and spatial data handling functions of Geographic Information Systems (GIS). Application of data modeling principles and geoprocessing capabilities using ArcGIS Pro: data design and modeling, data acquisition, data acquisition and integration, spatial analysis of vector and raster data, particular functions for digital terrain modeling and hydrology, map generation and 3D-visualization.</td>
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<td>Lecture notes</td>
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<td>Lecture Script: Introduction to Geographic Information Systems, Tutorial: Introduction to ArcGIS Pro. All lecture materials are provided digitally.</td>
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### Advanced

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<td>Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.</td>
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<td>Subject-specific Competencies</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<td></td>
<td>W. Behr, S. Willett</td>
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</table>
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales.

Assessment of mechanisms responsible for plate movements (the Earth as a heat transfer machine, dynamics of earth mantle, plate driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information.

Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Plate tectonics frame work: earth cooling and mantle-plate interaction, three kinds of plate boundaries and their roles and characteristics, cycle of oceanic lithosphere, longlifity and growth of continents, supercontinents.

Rheology of layered lithosphere and upper mantle.

Passive and active continental margin evolution


Literature


https://eth.wsiscovery.slsp.ch/permalink/41SLSP_ETHslih64/alma99117209929405503


https://eth.wsiscovery.slsp.ch/permalink/41SLSP_ETHslih64/alma99117212190205503

Prerequisites / notice

Lectures held by Prof. J. Aaron will be conducted in English. The lecture slides for these lectures will be available in both German and English. All other lecture material will be provided in German. The exam is held in German.

Students registering for the course confirm having read and accepted the terms and conditions for excursions and field courses of D-EAPS: https://www.ethz.ch/content/dam/ethz/education/de/ins/sid/excursions/AGB_ERDW_Exkursionen_en.pdf

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Critical Thinking

651-3541-00L Exploration and Environmental Geophysics W+ 4 credits 3V P. Edme. H. Maurer. A. Shakas

Abstract
Overview and understanding of the most important geophysical methods: Potential field methods (Gravimetrics and Magnetics), Electrical and electromagnetic methods, Refraction and reflection seismics, Georadar. Discussion of survey design, sources and receivers and data processing.

Objective
Overview and understanding of the most important geophysical methods. Proposed solutions to assess and observe problems relevant to exploration and environmental geophysics in soil, ice and lithosphere at different scales. Getting familiar with measuring- and interpretation procedures. Pointing out the possibilities and limitations of geophysical methods.

Content

Lecture notes
Available through Moodle / eDoz.

Additional material will be provided by the lecturers.

Literature


651-4903-00L Quaternary Geology and Geomorphology W+ 3 credits 2G S. Ivy Ochs. M. Luet scher, H. Stoll

Abstract
In this course the student is familiarized with the manner in which glacial, periglacial, fluvial, gravitational, karst, coastal and aeolian processes produce characteristic landforms and sedimentary deposits. The student is introduced to subdivisions of the Quaternary, with a focus on climatic changes in the Alps. Competency in these themes is gained through practical exercises and discussion.

Electives

The electives listed are recommended.

Additional courses can be chosen from the complete offerings of the ETH Zurich and University of Zurich.

Number Title Type ECTS Lecturers

651-3561-00L Cryosphere W 3 credits 2V M. Huss. D. Farinotti. H. J. Horgan

Abstract
The course introduces the different components of the cryosphere - snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their respective roles in the climate system. For each subsystem, essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.

Objective
Students are able to:
- qualitatively explain relevant processes, feedbacks and relationships between the different components of the cryosphere,
- quantify and interpret physical processes, which determine the state of the cryospheric components, with simple calculations.

In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined. In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

Content
The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, permafrost, and their roles in the climate system. Essential physical aspects are emphasized for each subsystem: e.g. the material properties of ice, mass balance and dynamics of glaciers, or the energy balance of sea ice.

Lecture notes
Handouts will be distributed during the teaching semester

Literature

Further literature will be indicated during the lecture.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1109 of 2667
This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk, and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts and a field trip.

By the end of the course, students will be able to:

- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- identify and discuss the development of natural hazards in the context of climate change.

Objectives

- Social Competencies
  - Communication
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-direction and Self-management

The students learn the principles of presenting scientific material orally. They become acquainted with the structure of scientific publications, and learn how to find, read and evaluate scientific literature. Furthermore, the course will introduce basic aspects of scientific writing.

**Bachelor's Seminar**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | Lecturers
---|---|---|---|---|---
651-3597-00L | Bachelor's Seminar I | O | 2 credits | 2G | H. Stoll, H. Busemann, J. D. Rickli

**Prerequisites / notice**

- Attendance of the lecture "Atmosphäre" LV 701-0023-00L or equivalent knowledge is a pre-requisite, and basic courses in physics and chemistry are expected.
- On Mondays (or upon agreement) a tutorial is offered. This allows the students to discuss unresolved issues from the lecture or to discuss the problems of the exercise series and their solution. Participation is recommended.

**Advanced**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | Lecturers
---|---|---|---|---|---
701-0471-01L | Atmospheric Chemistry | W | 3 credits | 2G | M. Ammann, C. Heald, C. Mohr

**Prerequisites / notice**

- Lecture materials (slides) are provided continuously during the semester, at least 2 days before each lecture. Annotations and corrections are provided at the latest within the same week.
- Attendance of the lecture "Atmosphäre" LV 701-0023-00L or equivalent knowledge is a pre-requisite, and basic courses in physics and chemistry are expected.
Abstract
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, especially prediction of showers and severe convective storms, and optical phenomena.

Objective
Students are able to:
- explain the mechanisms of convective storm formation using knowledge of thermodynamics and cloud microphysics.
- interpret precipitation radar images.
- evaluate the significance of clouds and aerosol particles for artificial weather modification.

Content
In the course "Atmospheric Physics", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined. Measurement methods are taught as well.

The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to use thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in radiosonde ascents. Atmospheric mixing processes are introduced as a basis for fog formation. The concept of an air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Lecture notes
Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=22731

Literature

An electronic version of this book can be obtained via the ETH library.

dbf-files of the revised book will be provided on moodle on a chapter-by-chapter basis.

Prerequisites / notice
We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Social Competencies
- Communication

Personal Competencies
- Critical Thinking
- Self-direction and Self-management

Further literature will be indicated during the lecture.

Weather Systems

Abstract
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes.

Objective
Students are able to:
- qualitatively explain relevant processes, feedbacks and relationships between the different components of the cryosphere,
- quantify and interpret physical processes, which determine the state of the cryospheric components, with simple calculations.

Content
In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, permafrost, and their roles in the climate system. Essential physical aspects are emphasized for each subsystem: e.g. the material properties of ice, mass balance and dynamics of glaciers, or the energy balance of sea ice.

Handouts will be distributed during the teaching semester.

Further literature will be indicated during the lecture.

701-0473-00L
Weather Systems

Abstract
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes.

Objective
Students are able to:
- to explain the mechanisms of convective storm formation using knowledge of thermodynamics and cloud microphysics.
- to interpret precipitation radar images.
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

Content
In the course "Atmospheric Physics", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined. Measurement methods are taught as well.

The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to use thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in radiosonde ascents. Atmospheric mixing processes are introduced as a basis for fog formation. The concept of an air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Lecture notes
Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=22731

Literature

An electronic version of this book can be obtained via the ETH library.

dbf-files of the revised book will be provided on moodle on a chapter-by-chapter basis.

Prerequisites / notice
We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Social Competencies
- Communication

Personal Competencies
- Critical Thinking
- Self-direction and Self-management

Further literature will be indicated during the lecture.
Objective
The students are able to
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems

Content
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

Lecture notes
Lecture notes and slides

Literature
Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

Prerequisites / notice
Basic physics

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving

Social Competencies
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual assessment, fostered

Abstract
The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making

Social Competencies
Cooperation and Teamwork

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Electives
The electives listed are recommended.
Additional courses can be chosen from the complete offerings of the ETH Zurich and University of Zurich.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.</td>
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<td>The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies. The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.</td>
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<td>Lecture notes</td>
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In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.
Objective

Students are able to:
- Characterize the different soils based on their key textural and structural properties.
- Simulate and predict soil water retention and flow under varying environmental conditions and understand the key driving forces (capillarity, gravity, friction) and related water properties (surface tension and viscosity).
- Predict soil hydraulic properties for varying soil textural classes.
- Predict solute transport in soils for varying environmental conditions.
- Predict energy balance and temperature dynamics in soils.
- Predict conditions for plant water stress
- Estimate the impact of soil properties on the hydrological cycle and on plant growth.

Content

INTRODUCTION

Week 1 (September 18)
Presentation of the role of soil physics in environmental sciences and terrestrial ecosystems: soils in the water cycle; soils and vegetation; soils and solute transport. Survey on students' interests and expectations. Presentation of course structure and learning objectives.

BASIC SOIL PROPERTIES

Week 2 (September 25) and Week 3 (October 02)
soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density
Pore scale consideration (water in a single pore), pore sizes and shapes; surface tension; Young-Laplace equation; capillary rise; contact angle
Friction and laminar flow; Hagen-Poiseuille's law; Washburn equation; numerical lab (REPORT 1)

SOIL HYDRAULIC PROPERTIES

Week 4 (October 09) and Week 5 (October 16)
Soil water content and soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point
Soil water characteristics and pore size distribution
Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts; effective conductivity; unsaturated hydraulic conductivity; Buckingham law.
Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications

TOOLBOX – MEASUREMENTS AND MODELING

Week 6 (October 23) and Week 7 (October 30)
Measuring soil hydraulic properties, fitting and interpretation; Lab tour - demonstration of soil physical methods; lecture on HYPROP method; report on Hyprop data (REPORT 2)
Modelling unsaturated water flow based on Richards equation - Using Hydrus1D for simulation of unsaturated flow; simulating HYPROP measurements (REPORT 3)

SOIL IN THE WATER CYCLE

Week 8 (November 06) – Week 9 (November 13)
Water infiltration - steady state solutions for infiltration; approximate solutions to infiltration (Green-Ampt, Philip); infiltration rate and ponding; outlook to preferential flow
Water evaporation - Energy balance and land atmosphere interactions - potential and actual evaporation, evaporation stages;

SOIL PLANT INTERACTIONS

Week 10 (November 20) Week 11 (November 27)
Root water uptake and transpiration – Theory and mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance.
Modelling root water uptake and transpiration; analytical approaches and modeling using Hydrus (REPORT 4)

SOLUTE TRANSPORT

Week 12 (December 04) Week 13 (December 11)
Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application
Transport of reactive substances, preferential flow, simulations with Hydrus

CLOSURE

Week 14 (December 18)
Summary, course synthesis, connections between the different topics, questions, exam preparation

Literature

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Leadership and Responsibility fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Choice of courses from the complete offerings of ETH.

701-0479-00L Environmental Fluid Dynamics W 3 credits 2G H. Wernli, L. Papritz
This course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.
The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for
assessed
Ausführliches Skript zur Vorlesung ist erhältlich.
assessed
assessed
Seminar for Bachelor Students: Atmosphere and
Lecturers
ECTS
Concepts and Theories
assessed
assessed
2V+1U
Concepts and Theories
assessed
W
assessed
Creative Thinking
assessed
Creative Thinking
assessed

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Autumn Semester 2024

Mathematics IV: Statistics
W
4 credits
2V+1U
N. Meinshausen

Objective
Students are able
- to name the basics, concepts and methods of environmental fluid dynamics.
- to understand and discuss the components of the basic physical equations
- to mathematically solve basic equations for simple problems of environmental fluid dynamics.

Content
Basic physical terminology and mathematical laws:
Continuum hypothesis, forces, constitutive laws, state equations and basic principles of thermodynamics, kinematics, laws of mass and momentum on rotating earth.
Concepts and illustrative flow systems: vorticity dynamics, boundary layers, instability, turbulence - with respect to environmental fluid systems.
Scale analysis: dimensionless variables and dynamical similarity, simplification of the fluid system, e.g. shallow water assumption, geostrophic flow.
Waves in environmental fluid systems.

Lecture notes
In english language
Will be presented in class.
See also: web-site.

Literature

Competencies
Subject-specific Competencies
Concepts and Theories
assessed
Method-specific Competencies
Analytical Competencies
assessed
Problem-solving
assessed
Personal Competencies
Creative Thinking
assessed

401-0624-00L
Using R for Data Analysis and Graphics (Part I)
W
1.5 credits
1G
A. Hauser

Objective
Capacity to learn from data; good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.

Content

Lecture notes
Ausführliches Skript zur Vorlesung ist erhältlich.

Literature

Prerequisites / notice
Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

Voraussetzungen: Mathematik I, II

401-0621-00L
Using R for Data Analysis and Graphics (Part I)
W
1.5 credits
1G
A. Hauser

Objective
The students will be able to use the software R for simple data analysis and graphics.

Content
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

Lecture notes
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Prerequisites / notice
The course resources will be provided via the Moodle web learning platform.
Subscribing via Mystudies *automatically* makes you a student participant of the Moodle course of this lecture, which is at
https://moodle-app2.let.ethz.ch/course/view.php?id=20847

Competencies
Subject-specific Competencies
Concepts and Theories
assessed
Method-specific Competencies
Analytical Competencies
assessed
Media and Digital Technologies
assessed
Problem-solving
assessed
Social Competencies
Cooperation and Teamwork
fostered
Personal Competencies
Creative Thinking
assessed

Laboratory Course

The practical takes place in spring semester.

Bachelor's Seminar

Number
Title
Type
ECTS
Hours
Lecturers
701-0459-00L
Seminar for Bachelor Students: Atmosphere and Climate
O
3 credits
2S
M. Windisch, O. Stebler
Abstract
The seminar brings together students in the field of atmosphere and climate. Based on classic and current scientific articles, presentation techniques (presentations, poster presentations) are practised and students get a first insight into research in the field of atmosphere and climate.

Objective
In this seminar, students learn how to read scientific publications and how to transfer the scientific knowledge to a broader audience by means of oral and poster presentations. Students also get insight into the different research areas at the Institute for Atmospheric and Climate Science.

Content
1st week: course organisation and presentation of the institute
2nd and 3rd week: introduction to oral presentation technique
11th week: introduction to poster presentation technique
12th and 13th week: poster design
14th week: concluding poster presentation

Lecture notes
Documents are offered via the course’s web page.

Literature
Documents are offered via the course’s web page.

Prerequisites / notice
This course can only be offered to a limited number of students, however, in any case for everybody having to attend it compulsory. We beg you to sign in to this course early.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
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<td>Method-specific Competencies</td>
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<td>Cooperation and Teamwork fostered</td>
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<td>Sensitivity to Diversity fostered</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<td></td>
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</tbody>
</table>

Science in Perspective

Language Courses

Bachelor’s Thesis
The Bachelor Thesis and Bachelor-Seminar are offered once per year in the 6th semester, in the spring semester.

Earth and Climate Sciences Bachelor - Key for Type

Key for Hours

ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
The main objectives are to acquire expertise in:

- Advanced knowledge in optical mineralogy
- Identification of methods to determine minerals in thin sections
- Identification and characterisation of metamorphic minerals
- Description of rocks. Derive correct petrographic rock name, based on modal abundance and microstructure/texture
- Interpretation of rock fabric/microstructure, parageneses and mineral reactions

Content

- Repetition of principal optical properties and of microscopic methods to identify minerals. Emphasis on interpretation of interference figures.
- Study typical metamorphic rocks in thin sections
- Description and interpretation of parageneseses and texture/microstructures. Study the age relationship of crystallisation and deformation.
- Estimation of metamorphic grade
- Quantification: To determine volume percentage of rock components
- Scientific documentation: Descriptions, drawings, photomicrography using different kinds of illumination and using plane- or circular-polarised light.

Lecture notes

handouts with additional information on theory and for exercises, in English.

Literature

- Nesse, W.D.: Introduction to optical mineralogy. 3. Ed. (2004). Figures from this book will be used in lectures. Besides the theory, this book describes all optical properties of important minerals. Petrographers working on varying types of silicate rocks should have a look at this book.
Also available in the D-ERDW library, NO building, on D-floor.

Prerequisites / notice

Participants should have basic knowledge in crystallography, mineralogy and petrology, and have taken practical courses in microscopy of thin sections, as well as lectures in metamorphic petrology and structural geology!

Other microscopy courses at department D-ERDW are on:
- magmatic rocks, following this course in second half of semester (P. Ulmer, IGP; Inst. for Geochemistry and Petrology)
- sedimentary rocks (Geol. Institute)
- ore minerals (reflected light microscopy, Th. Driesner, IGP)
- microstructures, deformed rocks (Geol. Institute)

Other microscope courses taught at ETH Zürich at the D-ERDW are:
- Reflected Light Microscopy and Ore Deposits Practical (T. Driesner)
- Sedimentary petrography and microscopy (V. Picotti & M.G. Fellin)
- Microscopy of metamorphic rocks (A. Galli)
- microstructures, deformed rocks (Geol. Institute)

Number of participants 24.
651-4051-00L  Reflected Light Microscopy and Ore Deposits

Objective
Introduction to reflected light microscopy. Use of the microscope. Identification of opaque minerals through the use of determination tables.

Content
Recognition of the most important ore minerals in polished section, interpretation of ore mineral textures from important ore deposit types (of hydrothermal, magmatic, sedimentary and metamorphic origin) in geological context.

Literature
Spry, P.G., Geddeskse, B.L. (1987) Tables for the determination of common opaque minerals. Econ. Geol. Publishing Company, New Haven, 52 pp. (Hands on table book with optical and other properties of most important ore minerals in reflected light. Reprints can still be obtained from the SEG online bookstore. Copies of this book will be used in the course throughout.)


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Mücke, A. (1989) Anleitung zur Erzmikroskopie. Enke, Stuttgart, 187 pp. (in German) (The technical part is a good German equivalent of Craig & Vaughan while the sections on textures and their interpretation is much less systematic.)


651-4113-00L  Sedimentary Petrography and Microscopy

Abstract
Microscopy of carbonate (1st half of semester) and siliciclastic rocks (2nd half) rocks as well as siliceous, phosphatic and evaporitic sediments.

Objective
Description of grains and cement/matrix, texture, classification of the main sedimentary rocks. Discussion and interpretation of the environment of sedimentation. Diagenetic Processes.

Content
Microscopy of carbonate and siliciclastic rocks, siliceous and phosphatic rocks, their origin and classification. Diagenesis.

Literature

Prerequisites / notice
The earlier attendance of other MSc microscopy courses (e.g. magmatic and metamorphic rocks) is not required if during the BSc a general course on microscopy of rocks was completed.

651-4055-00L  Analytical Methods in Petrology and Geology

Abstract
Practical work in analytical chemistry for Earth science students.

Objective
Knowledge of some analytical methods used in Earth sciences, introduction to data interpretation, writing of a scientific report.
Introduction to analytical geochemistry and atom physics, notably:
- X-ray diffraction (XRD),
- X-ray fluorescence analysis (XRF),
- Electron Probe Microanalyzer (EPMA),
- Laser Ablation Inductively Coupled Plasma Mass Spectroscopy (LA-ICP-MS),
- Mass spectroscopy for light isotopes.

**Lecture notes**
Short handouts for each analytical method.

**Competencies**

<table>
<thead>
<tr>
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<td>Self-direction and Self-management</td>
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**651-4117-00L Sediment Analysis**

*Prerequisite: Successful completion of the MSc-course “Sedimentology I” (651-4041-00L).*

**Abstract**
Theoretical background and application of some basic methods for sediment analysis.

**Objective**
The main goal is to learn how to apply the analysis of the texture and grain-size of sediments to constrain the sedimentary processes and environments.

**Content**
A one-day fieldtrip to a local outcrop to learn how to describe sediments in the field and to collect samples for grain-size and compositional analysis. Application of the same analytical techniques on samples of unknown origin: the sampling sites will be revealed at the end of the course. Discussion of the theoretical background and of the results in class. At the end of the course, the student will have to hand in a report with the presentation and discussion of all the data produced during the course.

**Lecture notes**
For the various analytical methods English texts will be provided in class.

**Literature**
Introduction to clastic sedimentology. R.J. Cheel, Brock University

**Prerequisites / notice**
Prerequisite: Successful completion of the MSc-course “Sedimentology I” (651-4041-00L).

**Competencies**

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**651-0046-00L Electron Microscopy Course (SEM and EPMA)**

*Prerequisite: Successful completion of the MSc-course “Sedimentology I” (651-4041-00L).*

**Abstract**
Theory and lab demo of scanning electron microscope (SEM) and electron microprobe analysis (EPMA) applied to geological materials: introduction to the instruments, interaction of electron with matter, electron imaging (SE, BSE, CL), electron backscatter diffraction (EBSD), X-ray analysis for the chemical characterisation of solid material at the micron-scale.

**Objective**
Understand how the instrument works, why it is used, and how the different signals are being generated and analysed. Ability to treat and present analytical results, such as calculating a mineral formula from a mineral analysis.

**Content**
Physical principles of electron microscopy: electron optics, interaction of electrons with matter, production of X-rays, interaction of X-rays with matter, X-rays detection and analysis. The second part of the course includes several demonstrations on various SEMs (at ERDW and ScopeM) and one EPMA at DERDW.

**Lecture notes**
Script will be provided, along with copies of the course presentations.

[HIGHLY recommended]

**Prerequisites / notice**
No prerequisite required beside basic knowledge of petrology and mineralogy. Attending the "Analytical Methods in Geology and Petrology" prior to this course is an advantage.

**Competencies**

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**651-4063-00L X-Ray Powder Diffraction**

*Prerequisite: Successful completion of the MSc-course “Sedimentology I” (651-4041-00L).*

**Abstract**
In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters.

**Objective**
Upon successful completion of this course students are able to:
- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data,
- communicate the results in a scientific report.

The competencies of system understanding, concept development, and measurement methods are taught and examined.
Content
- Fundamental principles of X-ray diffraction
- Setup and operation of X-ray diffractometers
- Interpretation of powder diffraction data
- Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

Lecture notes
- Selected handouts will be made available in the lecture

Literature

Prerequisites / notice
- The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.
- Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential.
- Software will be provided for future use on own Laptop.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: assessed
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Restricted Choice Modules Geology

A minimum of two restricted choice modules must be completed for the major Geology.

Biogeochemistry

Biogeochemistry: Compulsory Courses
The compulsory courses of the module take place in spring semester.

Biogeochemistry: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4043-00L</td>
<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
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Abstract
- The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

Objective
- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonates
- You will see carbonate and organic-rich carbon sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

Content
- carbonates; chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corg : CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine sediments through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

Lecture notes
- no script. scientific articles will be distributed during the course

Literature
- We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

Prerequisites / notice
- The grading of students is based on in-class exercises and end-semester examination.

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<tr>
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<tr>
<td>651-4057-00L</td>
<td>Climate History and Palaeoclimatology</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>H. Stoll, I. Hernández Almeida</td>
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</table>

Abstract
- Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.
The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

<table>
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### Sedimentology

#### Sedimentology: Courses of Choice

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<td>651-4043-00L</td>
<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
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**Abstract**

The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes in palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

**Objective**

- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonates
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

**Content**

- carbonates, chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corg : CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine carbonates through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

**Lecture notes**

no script. scientific articles will be distributed during the course

**Literature**

We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

**Prerequisites / notice**

The grading of students is based on in-class exercises and end-semester examination.

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### Sedimentology: Compulsory Courses

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<tr>
<td>651-4041-00L</td>
<td>Sedimentology I: Physical Processes and Sedimentary Systems</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Picotti</td>
</tr>
</tbody>
</table>

**Abstract**

Sediments preserved a record of past landscapes. This course focuses on understanding the processes that modify sedimentary landscapes with time and how we can read this changes in the sedimentary record.

**Objective**

The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change. They discuss the advantages and pitfalls of the method and look beyond. In particular we pay attention to introducing the importance of considering entire sediment routing systems and understanding their functioning.

**Content**

- carbonates, chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corg : CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine carbonates through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

**Lecture notes**

no script. scientific articles will be distributed during the course

**Literature**

The grading of students is based on in-class exercises and end-semester examination.

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### Sedimentology: Courses of Choice

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**Abstract**

The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes in palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

**Objective**

- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonates
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

**Content**

- carbonates, chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corg : CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine sediments through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

**Lecture notes**

no script. scientific articles will be distributed during the course

**Literature**

We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

**Prerequisites / notice**

The grading of students is based on in-class exercises and end-semester examination.
651-4901-00L Quaternary Dating Methods  

**Objective**  
Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

At the end of the course, students will:
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. choose which dating method (or combination of methods) suits a certain field problem.
3. critically read and evaluate the application of dating methods in scientific publications.

**Content**  
1. Introduction: Isotopes and decay
2. Radiocarbon dating: principles and applications
3. AMS technique and its application in Quaternary geochronology
4. U-series disequilibrium dating
5. Luminescence dating
6. Introduction to incremental: varve counting, dendrochronology, and ice cores chronologies
7. Dating anthropogenic records

**Prerequisites / notice**  
Visit to radiocarbon lab, cosmogenic nuclide lab, and accelerator (AMS) facility.

Required: attending the lecture, visiting laboratories, handing back solutions for problem sets, short presentations or written report

**Competencies**  

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| Personal Competencies | Critical Thinking | fostered |

651-4063-00L X-Ray Powder Diffraction  

**Objective**  
Upon successful completion of this course students are able to:
- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data,
- communicate the results in a scientific report.

The competencies of system understanding, concept development, and measurement methods are taught and examined.

**Content**  
Fundamental principles of X-ray diffraction
Setup and operation of X-ray diffractometers
Interpretation of powder diffraction data
Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

**Literature**  
  [Link](http://pubs.rsc.org/en/Content/eBook/978-0-85404-231-9)  

**Prerequisites / notice**  
The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.

**Competencies**  

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<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
<th>fostered</th>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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651-4341-00L Source to Sink Sedimentary Systems  

**Abstract**  
Transfer and redistribution of material on Earth's surface is controlled by myriad processes. To investigate these, this course will address the production, transport, and deposition of sediments and will probe their interactions with biogeochemical cycles. We will integrate catchment-scale sediment dynamics with associated (organic) carbon cycling at all stages of the "source to sink" continuum.
Objective
This course will integrate several Earth-science disciplines (geology, geomorphology, and biogeochemistry) to provide a holistic understanding of the physical and biogeochemical processes that control sediment and (organic) carbon production and mobilization along geomorphic cascades. The primary objective is to track the evolution of a particle as it is produced by rock weathering, transformed during soil development, eroded and transported by fluvial processes, and eventually buried in depositional systems. In doing so, students will learn how to “see a world through a grain of sand.”

Content
This course will comprise three main components:
(i) Lectures will introduce the main “source to sink” concepts and will focus on both physical and biogeochemical processes from uplands, sediment-producing regions to lowland, sediment-depositing regions (i.e., erosion and mass movements; hillslopes, soil development, and the “critical zone”); transport and storage in rivers and floodplains; and deposition in sedimentary archives.
(ii) A three-day field excursion from the Rhône Glacier to the Rhône Delta in Lake Geneva (Sept. 27-29, 2024) will provide hands-on examples of these concepts within the upper Rhône Basin. During the excursion, students will present a summary of an assigned relevant scientific paper and will sample solid- and dissolved-phase materials (soils, sediments, river water) from different geomorphic settings and upstream to downstream fluvial environments; these samples will form the basis of two laboratory-based practical exercises.
(iii) Practicals will comprise two group exercises: (1) an assessment of Rhône river chemical weathering, including its erosional and lithological controls, using dissolved river-water samples; and (2) an investigation of Alpine soil formation and erosion, including its lithological and environmental controls, using solid-phase soil and sediment samples. For both practicals, students will learn relevant analytical instrumentation; generate data using samples collected in the field; and write a scientific report on their findings, environmental context, and interpretation within the “source to sink” concept.

Grading will be distributed as: 30% field excursion participation and literature review, 35% Practical 1, 35% Practical 2.

Lecture notes
Lecture notes will be provided online during the course. These will provide necessary theoretical background, summarize relevant “source to sink” topics, and serve as the basis for knowledge to be incorporated into both Practical assignments.

Literature
Prior knowledge on the fundamentals of geomorphology, (bio)geochemistry, and/or soil science is highly encouraged. While not strictly required, additional suggested literature includes:
- "Sediment routing systems: the fate of sediments from Source to Sink" by Philip A. Allen (Cambridge University Press)
- “Principles of soilscape and landscape evolution” by Garry Willgoose (Cambridge University Press)
- "Geomorphology, the mechanics and chemistry of landscapes” by Robert S. Anderson & Suzanne P. Anderson (Cambridge University Press)

651-4243-00L Seismic Stratigraphy and Facies
Objective
1. Acquire techniques for a comprehensive interpretation of seismic sections for solving geologic, stratigraphic and environmental problems
2. Correlation of seismic facies and seismic attributes to lithologic facies in different sedimentary systems
3. Learn the principles and techniques of seismic sequence stratigraphy and the differences between lithostratigraphy and sequence stratigraphy
4. Learn to integrate seismic data into paleoceanographic and paleoclimatic research.

Abstract
The course teaches the techniques of seismic interpretation for solving geological and environmental problems. A special focus is given to the seismic facies analysis and seismic sequence stratigraphy of different depositional systems. In addition, examples are presented how seismic data can be integrated into research projects in basin analysis, paleoceanography and paleoclimatology.

Content
The four day course consists of lectures that are accompanied by a variety of exercises.

Day 1:
Introduction seismic facies analysis with exercise
Seismic resolution
Seismic facies of contourite drift systems and their value as physical indicators of global current changes.

Day 2:
Seismic attributes and seismic geomorphology
Siliciclastic deltas, shelves and turbidite systems, 2D-3D
Exercise: Seismic section Tarragon Basin and reconstructing the basin evolution with respect to the climate conditions at the end of the Miocene.
Seismic facies carbonate systems
Carbonates as recorders of sea level and paleoclimate
Deepwater environments, including cold-water coral habitats

Day 3:
Carbonates versus volcanic seismic facies
Introduction seismic attributes
Faults and structures on seismic sections
Seismic facies of mixed systems with
Exercises from Canada and the Paradox Basin

Day 4:
Sea level and sedimentation
Telling ages on seismic section
Seismic stratigraphy and sequence stratigraphy
Exercise: Sequence analysis Straits of Andros
Final discussion

Lecture notes
An original script (110 pages) designed for the class will be distributed at the beginning of the course.
The objective of this course is to introduce rock physics and rock deformation, and discuss the aid of laboratory tests to interpretation at exploration and production. AAAG Studies in Geology, No. 42 and SEG Geophysical Development Series, No. 5., pp. 270.


The course will focus on research-based term project, lectures will alternate with laboratory demonstrations. We will illustrate how intrinsic properties of rocks (mineral composition, porosity, pore fluids, crystallographic orientation, microstructures) are connected to the following physical properties:
- permeability;
- elastic properties for seismic interpretations;
- anisotropy of the above physical properties.
We will measure some of those parameters in laboratory and discuss real case studies and applications.

Principles of deformation mechanisms, flow laws, and deformation mechanism maps will be presented in lectures. In laboratory we will show:
- Experimental deformation rigs (gas, fluid and solid confining media);
- Main part of the apparatus (mechanical, hydraulic, heating system, data logging);
- Calibration of an apparatus (distortion of the rig; transducers calibration);
- Various types of tests (axial deformation; diagonal cut and torsion; deformation; constant strain rate tests; creep tests; stepping tests).

Prerequisites / notice
The course of Structural Geology (651-3422-00L) is highly recommended before attending this course.
Moreover the students should have basic knowledge in geophysics and mineralogy/crystallography.

In doubt, please contact the course responsible beforehand.

651-3521-00L Tectonics W 3 credits 2V W. Behr, S. Willett

Abstract
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Objective
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Assessment of mechanisms responsible for plate movements (the Earth as a heat transfer machine, dynamics of earth mantle, plate driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Content

Literature

Open Choice Modules Geology
Basin Analysis
Basin Analysis: Compulsory Courses

Number Title Type ECTS Hours Lecturers
651-4341-00L Source to Sink Sedimentary Systems W+ 3 credits 2G T. I. Eglinton, J. Hemingway, L. Bröder, M. Grieponentg

Abstract
Transfer and redistribution of material on Earth's surface is controlled by myriad processes. To investigate these, this course will address the production, transport, and deposition of sediments and will probe their interactions with biogeochemical cycles. We will integrate catchment-scale sediment dynamics with associated (organic) carbon cycling at all stages of the "source to sink" continuum.

Objective
This course will integrate several Earth-science disciplines (geology, geomorphology, and biogeochemistry) to provide a holistic understanding of the physical and biogeochemical processes that control sediment and (organic) carbon production and mobilization along geomorphic cascades. The primary objective is to track the evolution of a particle as it is produced by rock weathering, transformed during soil development, eroded and transported by fluvial processes, and eventually buried in depositional systems. In doing so, students will learn how to "see a world through a grain of sand."

Content
This course will comprise three main components:
(i) Lectures will introduce the main "source to sink" concepts and will focus on both physical and biogeochemical processes from uplands, sediment-producing regions to lowland, sediment-depositing regions (i.e., erosion and mass movements; hillslopes, soil development, and the "critical zone"); transport and storage in rivers and floodplains; and deposition in sedimentary archives.
(ii) A three-day field excursion from the Rhône Glacier to the Rhône Delta in Lake Geneva (Sept. 27-29, 2024) will provide hands-on examples of these concepts within the upper Rhône Basin. During the excursion, students will present a summary of an assigned relevant scientific paper and will sample solid- and dissolved-phase materials (soils, sediments, river water) from different geomorphic settings and upstream to downstream fluvial environments; these samples will form the basis of two laboratory-based practical exercises.
(iii) Practical exercises will comprise two group exercises: (1) an assessment of Rhône river chemical weathering, including its erosional and lithological controls, using dissolved river-water samples; and (2) an investigation of Alpine soil formation and erosion, including its lithological and environmental controls, using solid-phase soil and sediment samples. For both practicals, students will learn relevant analytical instrumentation; generate data using samples collected in the field; and write a scientific report on their findings, environmental context, and interpretation within the "source to sink" concept.
Grading will be distributed as: 30% field excursion participation and literature review, 35% Practical 1, 35% Practical 2.

Lecture notes
Lecture notes will be provided online during the course. These will provide necessary theoretical background, summarize relevant "source to sink" topics, and serve as the basis for knowledge to be incorporated into both Practical assignments.
Prior knowledge on the fundamentals of geomorphology, (bio)geochemistry, and/or soil science is highly encouraged. While not strictly required, additional suggested literature includes:
- "Sediment routing systems: the fate of sediments from Source to Sink" by Philip A. Allen (Cambridge University Press)
- "Principles of soilscape and landscape evolution" by Garry Willgoose (Cambridge University Press)
- "Geomorphology, the mechanics and chemistry of landscapes" by Robert S. Anderson & Suzanne P. Anderson (Cambridge University Press)

### Competencies

#### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies
- Analytical Competencies
- Project Management

#### Social Competencies
- Communication
- Cooperation and Teamwork

#### Personal Competencies
- Critical Thinking

### Basin Analysis: Courses of Choice

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4243-00L</td>
<td>Seismic Stratigraphy and Facies</td>
<td>W+</td>
<td>2 credits</td>
<td>3G</td>
<td>G. Eberli</td>
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</table>

#### Abstract
The course teaches the techniques of seismic interpretation for solving geological and environmental problems. A special focus is given to the seismic facies analysis and seismic sequence stratigraphy of different depositional systems. In addition, examples are presented how seismic data can be integrated into research projects in basin analysis, paleoceanography and paleoclimatology.

#### Objective
1. Acquire techniques for a comprehensive interpretation of seismic sections for solving geologic, stratigraphic and environmental problems
2. Correlation of seismic facies and seismic attributes to lithologic facies in different sedimentary systems
3. Learn the principles and techniques of seismic sequence stratigraphy and the differences between lithostratigraphy and sequence stratigraphy
4. Learn to integrate seismic data into paleoceanographic and paleoclimatic research.

#### Content
The four day course consists of lectures that are accompanied by a variety of exercises.

**Day 1:**
- Introduction seismic facies analysis with exercise
- Seismic resolution
- Seismic facies of contourite drift systems and their value as physical indicators of global current changes.

**Day 2:**
- Seismic attributes and seismic geomorphology
- Siliciclastic deltas, shelves and turbidite systems, 2D-3D
- Exercise: Seismic section Tarragon Basin and reconstructing the basin evolution with respect to the climate conditions at the end of the Miocene.
- Seismic facies carbonate systems
- Carbonates as recorders of sea level and paleoclimate
- Deepwater environments, including cold-water coral habitats

**Day 3:**
- Carbonates versus volcanic seismic facies
- Introduction seismic attributes
- Faults and structures on seismic sections
- Seismic facies of mixed systems with exercises from Canada and the Paradox Basin

**Day 4:**
- Sea level and sedimentation
- Telling ages on seismic section
- Seismic stratigraphy and sequence stratigraphy
- Exercise: Sequence analysis Straits of Andros
- Final discussion

#### Literature

#### Prerequisites / notice
Basic knowledge in sedimentology and stratigraphy
Earthquake Seismology

### Earthquake Seismology: Compulsory Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>651-4021-00L</td>
<td>Engineering Seismology</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>P. Bergamo, M. Koroni</td>
</tr>
</tbody>
</table>

#### Abstract
This course is a general introduction to the methods of seismic hazard analysis. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties.

#### Objective
This course is a general introduction to the methods of seismic hazard analysis.

#### Content
In the course it is explained how the disciplines of seismology, geology, strong-motion geophysics, and earthquake engineering contribute to the evaluation of seismic hazard. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties. The course includes the discussion related to intensity and macroseismic scales, historical seismicity and earthquake catalogues, ground motion parameters used in earthquake engineering, definitions of the seismic source, ground motion attenuation, site effects and microzonation, and the use of numerical tools to estimate ground motion parameters, both in a deterministic and probabilistic sense.

During the course recent earthquakes and their impacts are discussed and related to existing hazard assessments for the areas of interest.

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<tbody>
<tr>
<td>651-4015-00L</td>
<td>Earthquakes I: Seismotectonics</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>A. P. Rinaldi, T. Diehl</td>
</tr>
</tbody>
</table>

#### Abstract
If you're interested in knowing more about the relationship between seismicity and plate tectonics, this is the course for you. (If you're not that interested, but your program of study requires that you complete this course, this is also the course for you.)

#### Objective
The aim of the course is to obtain a basic understanding of the physical process behind earthquakes and their basic mathematical description. By the conclusion of this course, we hope that you will be able to:
- describe the relationship between earthquakes and plate tectonics in a more sophisticated and complete way
- explain earthquake source representations of varying complexity;
- address earthquakes in the context of different tectonic settings;
- explain the statistical behaviour of global earthquakes;
- describe and connect the ingredients for a seismotectonic study.

#### Content
The course features a series of 14 meetings, in which we review some fundamentals of continuum mechanics and tensor analysis required for a complete understanding of the relation between earthquakes and plate tectonics. Our goal is to help you understand deformation the small scale (fault) to the scale of plate tectonics. We will tell you about several ways to represent an earthquake source; we'll present these in order of increasing sophistication. You will enjoy (at least) a computer/class exercise and a guest lecture.

Topics covered in the course include:
- review of stress and deformation in the Earth, stress and strain tensors, theory and failure criteria, fault stresses, friction and effects of fluids
- earthquake focal mechanisms; relationship between stress fields and focal mechanisms;
- seismic moment and moment tensors;
- crustal deformation from seismic, geologic, and geodetic observations;
- earthquake stress drop, scaling, and source parameters;
- global earthquake distribution; current global earthquake activity;
- different seismotectonic regions; examples of earthquake activity in different tectonic settings.

#### Lecture notes
Course notes will be made available on a designated course web site. Most of the topics discussed in the course are available in the book mentioned below.

#### Literature

#### Prerequisites / notice
Basic knowledge of continuum mechanics and rock mechanics, as well as notion of tensor analysis is strongly suggested. We recommend to have taken the course Continuum Mechanics (generally taught during the Fall semester).

This course will be taught in fall 2017 and it will be followed by Earthquakes 2: Source Physics in Spring 2018.

The course will be evaluated in a final written test covering the topics discussed during the lectures.

The course will be worth 3 credit points, and a satisfactory total grade (4 or better) is needed to obtain 3 ECTS.

The course will be given in English.

### Geographic Information Systems

#### Geographic Information Systems: Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4267-00L</td>
<td>Advanced Geographic Information Science V</td>
<td>W+</td>
<td>5</td>
<td>2V+2U</td>
<td>University lecturers</td>
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</table>

### Notice
Mind the enrolment deadlines at UZH:
The course provides an in-depth study of basic concepts and techniques of GIS at an advanced level. This is intended to provide a foundation for independent and well-informed development of GIS application projects.

- Knowledge of important terms and aspects of spatial data quality and data uncertainty, and can discuss them for given data.
- Ability to discuss and compare alternative algorithms and implementations for given spatial problems.
- Ability to propose relevant GIS analyses and their implementation for complex spatial problems and to justify your choice.
- Understanding the important relationship between GIS and spatial databases as well as the increasing importance of internet applications of spatial data.

### Geographic Information Systems: Courses of Choice

The Courses of Choice are offered by UZH and must be approved by the subject advisor.

#### Geographic Data Processing with Python and ArcGIS

**Type**: W  
**ECTS**: 1  
**Hours**: 2U  
**Lecturers**: A. Baltensweiler

This elective module provides an in-depth study of basic concepts and techniques of GIS at an advanced level. This is intended to provide a foundation for independent and well-informed development of GIS application projects.

- Knowledge of important terms and aspects of spatial data quality and data uncertainty, and can discuss them for given data.
- Ability to discuss and compare alternative algorithms and implementations for given spatial problems.
- Ability to propose relevant GIS analyses and their implementation for complex spatial problems and to justify your choice.
- Understanding the important relationship between GIS and spatial databases as well as the increasing importance of internet applications of spatial data.

### Glaciology

#### Glaciology: Compulsory Courses

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<tr>
<th>Number</th>
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<tr>
<td>651-3561-00L</td>
<td>Cryosphere</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Huss, D. Farinotti, H. J. Horgan</td>
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</table>

The course introduces the different components of the cryosphere - snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their roles in the climate system. Essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.

- Students are able to:
  - qualitatively explain relevant processes, feedbacks and relationships between the different components of the cryosphere,
  - quantify and interpret physical processes, which determine the state of the cryospheric components, with simple calculations.

In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

#### Literature


Further literature will be indicated during the lecture.
Seminar in Glaciology

Abstract
Introduction to classic and modern literature of research in Glaciology. Active participation is expected and participants are mentored by PhD students of Glaciology.

Objective
In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

Content
Selected topics of scientific research in Glaciology

Lecture notes
Copies/pdf of scientific papers will be distributed during the course (moodle interface)

Prerequisites / notice
Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:
- 651-3561-00L Kryosphäre
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers

Competencies
Subject-specific Competencies
Concepts and Theories
- fostered
Techniques and Technologies
- fostered

Method-specific Competencies
Analytical Competencies
- fostered
Decision-making
- fostered

Social Competencies
Communication
- fostered
Cooperation and Teamwork
- fostered
Self-presentation and Social Influence
- fostered
Sensitivity to Diversity
- fostered
Negotiation
- fostered

Personal Competencies
Adaptability and Flexibility
- fostered
Creative Thinking
- fostered
Critical Thinking
- fostered
Self-awareness and Self-reflection
- fostered
Negotiation
- fostered

Quantification and Modeling of the Cryosphere:
Dynamic Processes (University of Zurich)

Abstract
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: GEC815

Objective
This course introduces quantitative approaches and models to processes of the cryosphere in high mountain areas. The main focus are dynamic and thermal processes related to glaciers and permafrost. During the course, simple simple mathematical and numerical models will be used to investigate ground temperature profiles as well as glacier evolution and dynamics in relation to climate.

Content
For the modeling and project parts of the course, programs written in the Python programming language are used. Prior Python or programming knowledge is not necessary, and introductory tutorials are given.

Physics of Glaciers

Abstract
Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

Objective
After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

Content
The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Lecture notes
Will be provided on Moodle

Literature
A list of relevant literature is available on Moodle

Prerequisites / notice
High-school mathematics and physics knowledge required.
The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

Objective
The objectives of the courses are to:
- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

Content
The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Abstract
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Objective
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Assessment of mechanisms responsible for plate movements (the Earth as a heat transfer machine, dynamics of earth mantle, plate driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Content
Plate tectonic frame work: earth cooling and mantle-plate interaction, three kinds of plate boundaries and their roles and characteristics, cycle of oceanic lithosphere, longfity and growth of continents, supercontinents. Rheology of layered lithosphere and upper mantle. Obduction systems Collisions systems Extensional systems Basin evolution Passive and active continental margin evolution
651-4015-00L Earthquakes I: Seismotectonics 3 credits 2G A. P. Rinaldi, T. Diehl

Abstract
If you’re interested in knowing more about the relationship between seismicity and plate tectonics, this is the course for you. (If you’re not that interested, but your program of study requires that you complete this course, this is also the course for you.)

Objective
The aim of the course is to obtain a basic understanding of the physical process behind earthquakes and their basic mathematical description. By the conclusion of this course, we hope that you will be able to:
- describe the relationship between earthquakes and plate tectonics in a more sophisticated and complete way
- explain earthquake source representations of varying complexity
- address earthquakes in the context of different tectonic settings
- explain the statistical behaviour of global earthquakes
- describe and connect the ingredients for a seismotectonic study

Content
The course features a series of 14 meetings, in which we review some fundamentals of continuum mechanics and tensor analysis required for a complete understanding of the relation between earthquakes and plate tectonics. Our goal is to help you understand deformation in the small scale (fault) to the scale of plate tectonics. We will tell you about several ways to represent an earthquake source; we’ll present these in order of increasing sophistication. You will enjoy (at least) a computer/class exercise and a guest lecture.

Topics covered in the course include:
- review of stress and deformation in the Earth, stress and strain tensors, rheology and failure criteria, fault stresses, friction and effects of fluids
- earthquake focal mechanisms; relationship between stress fields and focal mechanisms; seismic moment and moment tensors; crustal deformation from seismic, geologic, and geodetic observations; earthquake stress drop, scaling, and source parameters; global earthquake distribution; current global earthquake activity; different seismotectonic regions; examples of earthquake activity in different tectonic settings.

Lecture notes
Course notes will be made available on a designated course web site. Most of the topics discussed in the course are available in the book mentioned below.

Literature

Prerequisites / notice
Basic knowledge of continuum mechanics and rock mechanics, as well as notion of tensor analysis is strongly suggested. We recommend to have taken the course Continuum Mechanics (generally taught during the Fall semester).

This course will be taught in fall 2017 and it will be followed by Earthquakes 2: Source Physics in Spring 2018.

The course will be evaluated in a final written test covering the topics discussed during the lectures.

The course will be worth 3 credit points, and a satisfactory total grade (4 or better) is needed to obtain 3 ECTS.

The course will be given in English.

651-4014-00L Seismic Waves II 3 credits 2G T. Diehl, F. Lanza, A. Obermann

Abstract
This course provides an overview on the most widely used seismological methods to image the Earth’s interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body-wave and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.

Objective
Understand the strengths and weaknesses of various active and passive tomographic methods to image the structure of the Earth.

Literature

Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: fostered
  - Decision-making: fostered
  - Problem-solving: fostered
- Social Competencies
  - Cooperation and Teamwork: fostered
- Personal Competencies
  - Creative Thinking: fostered
  - Critical Thinking: fostered

Palaeontology
Palaeontology: Compulsory Courses

The compulsory courses take place in spring semester.

Palaeontology: Courses of Choice

The courses of choice are offered by the Climate Geology group or UZH.
1. Introduction: Isotopes and decay fostering of student... M. Christl

ECTS I. Hajdas

Quantification and Modeling of the Cryosphere: Paleontological Excursions on Weekends (University of Zurich) No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: BIO279

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract Usually one to three day excursions (possibly including museum visits) to deepen regional geological and evolutionary knowledge and to gain practical paleontological experience.

Prerequisites / notice The course will only take place, if specific excursions are planned for the semester: https://www.pim.uzh.ch/studium/exkursionen/ Only in case a planned excursion is advertised, signing up for BIO 279 will be possible via the secretary office of the Paleontological Institute, UZH main building. Limited number of participants. Consideration after receipt of the registration. Please note the respective registration deadline. Further details can be found in the respective advertisements on the above-mentioned website.

Quaternary Geology and Geomorphology

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>651-4901-00L</td>
<td>Quaternary Dating Methods</td>
<td>W+</td>
<td>2 credits</td>
<td>1G</td>
<td>I. Hajdas, M. Christl</td>
</tr>
</tbody>
</table>

Abstract Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

Objective At the end of the course, students will:
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. choose which dating method (or combination of methods) suits a certain field problem.
3. critically read and evaluate the application of dating methods in scientific publications.

Content

- Introduction: Isotopes and decay
- Radiocarbon dating: principles and applications
- AMS technique and its application in Quaternary geochronology
- U-series disequilibrium dating
- Luminescence dating
- Introduction to incremental: varve counting, dendrochronology, and ice cores chronologies

Prerequisites / notice Visit to radiocarbon lab, cosmogenic nuclide lab, and accelerator (AMS) facility.

Competencies

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<tr>
<th>Competency Type</th>
<th>Competency</th>
<th>Fostered</th>
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<tbody>
<tr>
<td>Optional (individual):</td>
<td>1-5 days of hands-on radiocarbon dating at the 14C lab, ETH Hoenggerberg</td>
<td>fostered</td>
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Remote Sensing

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<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4077-00L</td>
<td>Quantiﬁcation and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)</td>
<td>W+</td>
<td>3 credits</td>
<td>1V</td>
<td>University lecturers</td>
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</tbody>
</table>

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract This course introduces quantitative approaches and models to processes of the cryosphere in high mountain areas. The main focus are dynamic and thermal processes related to glaciers and permafrost. During the course, simple simple mathematical and numerical models will be used to investigate ground temperature proﬁles as well as glacier evolution and dynamics in relation to climate.

Objective This course combines lectures providing the background on the physical processes and methods with computer practicals in which quantitative methods are applied to glaciers and permafrost processes. These lectures and practicals run as 2-hour blocks per week and are combined with group and individual exercises. Topics indicative for the content of this course are:

- Heat flow processes in the ground and in glaciers, and their solution with numerical models.
- Glacier dynamics and evolution in relation to climate change.
- Simple and reduced mathematical models for glaciers flow.
- Numerical models for glacier dynamics.

Content For the modeling and project parts of the course, programs written in the Python programming language are used. Prior Python or programming knowledge is not necessary, and introductory tutorials are given.

The course starts with lectures introducing the basic concepts of the different topics. The main focus lies on extensive computer practicals in which the related quantitative methods and models are applied and explored. Extensive group work on a topic of choice, using the quantitative models, will give a deep understanding how computer models are used in applied science.
The courses of this module are offered by UZH and must be registered at UZH.

Remote Sensing: Compulsory Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>651-4263-00L</td>
<td>Remote Sensing and Geographic Information Science V (University of Zurich)</td>
<td>W</td>
<td>5 credits</td>
<td>2V+2U</td>
<td>University lecturers</td>
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</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO371

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract
The course "Methoden der Fernerkundung" (Remote Sensing Methods) introduces advanced remote sensing methods and techniques for interpreting and analysing optical, RADAR and LiDAR data. The large variety of topics covered in this module range from radiative transfer over environmental monitoring to geometric and radiometric data processing techniques.

Objective
At the end of the module, students should: • Have a thorough understanding of advanced image understanding techniques and can apply these to optical, RADAR and LiDAR imagery. • Be able to choose the appropriate methods and use them to solve a given real-world task. • Be able to write basic programming scripts and use common remote sensing software to analyze geospatial data. • Be able to work scientifically on a given project (e.g. defining hypothesis and research questions). • Be able to comprehensively interpret data, critically discuss the results and draw the main conclusions.

Remote Sensing: Courses of Choice

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<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>651-4269-00L</td>
<td>Specialisation in Remote Sensing: Spectroscopy of the Earth System (University of Zurich)</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>University lecturers</td>
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</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO442

Prerequisite: Remote Sensing Methods (UZH Module Code: GEO371)

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract
The Spectroscopy of the Earth System course series outlines key contributions of imaging spectroscopy to advance understanding of the Earth System. Various Earth spheres (i.e. Atmosphere, Biosphere, Cryosphere, Hydrosphere, and Pedosphere) are addressed and spectroscopic approaches to quantify biogeophysical ecosystem properties and Earth surface processes are discussed.

Objective
The aim of the module is to give students a thorough understanding of the concepts, principles and processing of imaging spectroscopy data applied to various spheres of the Earth system. Students will be able to carry out typical workflows in data acquisition, processing and product generation. They will be able to assess the quality of the product and understand the nature of the errors affecting the product. Students will acquire both theoretical and practical knowledge and understanding of ground-based, aerial and satellite spectrometry data. They will be able to derive solutions to given problems and have an understanding of diverse Earth sphere applications and associated limitations of learned techniques.

Content
The individual lectures inherently focus on fundamentals of radiation interaction with the atmosphere and the surface, as well as on aspects of data acquisition, quality assessment and pre-processing. A comprehensive set of methods to extract information from imaging spectroscopy data is described (e.g. spectral feature analysis, spectral unmixing, radiative transfer modeling, reflectance and fluorescence retrieval, calculation of spectral albedo). The module is composed of the lecture GEO 442.1, outlining the underlying principles, and the exercise GEO442.2, conveying important methods and skills of data processing and analysis.

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<tr>
<td>651-4257-00L</td>
<td>Specialisation in Remote Sensing: SAR and LiDAR (University of Zurich)</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>University lecturers</td>
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</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO443

Prerequisite: Remote Sensing Methods (UZH Module Code: GEO371)

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract
This module introduces advanced remote sensing methods and techniques to interpret and analyse RADAR and LiDAR data. The variety of topics covered in this module begin with image focussing, move through geometric and radiometric data processing, as well as interferometric and polariometric evaluations.

Objective
The aim of the module is to give students a thorough understanding of the concepts, principles and processing of SAR and LiDAR data. Students will be able to carry out typical workflows in data processing and product generation. They will also be able to assess the quality of data products and understand the nature of errors that can affect the datasets. Students will acquire both theoretical and practical knowledge and understanding of airborne and satellite SAR imagery and LiDAR point cloud data. They will be able to derive solutions to problems presented and will have an understanding of applications including associated limitations.

Content
The module provides students with the skills to use state of the art software tools (e.g. SNAP, Matlab) to process data sets and develop new tools within existing frameworks. Examples of SAR applications treated include glacier and volcano monitoring, as well as height estimation using interferometry. Laser scanning exercises are focused on understanding LiDAR intensity, terrain model creation and their respective uncertainties and terrestrial laser scanning methods and applications. The module is composed of the lecture GEO 443.1, which teaches the underlying principles, and the exercise GEO443.2, which conveys important methods and skills of data processing and analysis.

Shallow Earth Geophysics

Courses are only offered in spring semester.

Modules from the Engineering Geology Major
All modules of the MSc in Earth Sciences are available as module of choice.

Modules from Engineering Geology

Modules from the Geophysics Major

Modules from the Mineralogy and Geochemistry Major

Open Choice Modules Mineralogy and Geochemistry

Modules from the Major Geology Restricted Choice Modules

Modules of restricted Choice Geology

Major in Engineering Geology

Compulsory Modules Engineering Geology

Engineering Geology: Fundamentals

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>651-4025-00L</td>
<td>Rock Mechanics and Rock Engineering</td>
<td>W+</td>
<td>4 credits</td>
<td>4V</td>
<td>V. Gischig, P. A. Selvadurai</td>
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<td>Abstract</td>
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<td>The course focusses on the fundamentals and basic concepts of rock mechanics and rock engineering (e.g. tunnelling, rock slope stability). The link between rock mechanics, geology, hydrogeology and tectonics (i.e. the conditions under which the rock formed) will be clearly established. The student shall understand basic principles of rock mechanics and rock engineering. In addition, the student shall learn how to apply the results from lab and field investigations to simple engineering problems. This knowledge is required for subsequent integration courses (Landslide Analysis and Hazard Mitigation; Engineering Geology of Underground Excavations).</td>
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<td>This course focusses on the fundamentals and basic concepts of rock mechanics and rock engineering. The course is compulsory for the MSc Eng Geol. The applications of rock mechanical principles and rock engineering methods are extensively covered in subsequent courses.</td>
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<td>Lecture notes</td>
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<td>Written course documentation available on our homepage: <a href="https://www.ethz.ch/content/specialinterest/erdw/geological-institute/engineering-geology/en/teaching/msc/fall/rock_mechanics.html">https://www.ethz.ch/content/specialinterest/erdw/geological-institute/engineering-geology/en/teaching/msc/fall/rock_mechanics.html</a></td>
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<tr>
<td>651-4033-00L</td>
<td>Soil Mechanics and Foundation Engineering</td>
<td>W+</td>
<td>4 credits</td>
<td>3V</td>
<td>J. Aaron, L. de Palézieux dit Falconnet, S. Montani</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>The course presents the principles of soil mechanics and soil behaviour characteristics and its applications in geotechnical structures and systems. It is based on more descriptive courses on Engineering Geology within the BSc Geol. Program and is a compulsory prerequisite for other courses within the MSc Eng. Geol. program. Understanding the principles of soil behaviour and the fundamentals of geotechnical practices in soils. Ability to communicate with geotechnical engineers. Fundamental concepts of strength and deformation of different soils. Introduction to geotechnical calculations Significance of (ground)water Geotechnical Engineering in Soils: Evaluation of geotechnical scenarios, handling of forecast uncertainties, relation of soil properties and soil composition, interactions between soil and building, standard construction methods in soils (foundations, slopes, dams and levees), requirements for the geotechnical prognosis</td>
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<td></td>
<td>Content</td>
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<td></td>
<td>This lecture is supported by the textbook: &quot;Geotechnical Engineering&quot; by Donald P. Coduto, 2nd edition, 2011; ISBN-13: 978-0-13-135425-8</td>
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<td>Prerequisites / notice</td>
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<td>Courses must be completed:</td>
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<tr>
<td></td>
<td>Introduction to Engineering Geology (BSc level)</td>
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<td></td>
<td>Introduction to Groundwater</td>
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<td>Sedimentology and Quaternary deposits</td>
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<td>Principles of Physics</td>
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<td>Courses recommended:</td>
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<td>Eng Geol Site Investigations</td>
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<td>Eng Geol Field Course I (soils)</td>
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<td>Clay Mineralogy</td>
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<tr>
<td>651-4023-00L</td>
<td>Groundwater</td>
<td>W+</td>
<td>4 credits</td>
<td>4G</td>
<td>X.-Z. Kong, B. Marti</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>The course provides an introduction into quantitative analysis of groundwater flow and solute transport. It is focussed on understanding, formulating, and solving groundwater flow and solute transport problems. a) Students understand the basic concepts of groundwater flow and solute transport processes, and boundary conditions. b) Students are able to formulate simple, practical groundwater flow and solute transport problems. c) Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems.</td>
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<td>a) Students understand the basic concepts of groundwater flow and solute transport processes, and boundary conditions. b) Students are able to formulate simple, practical groundwater flow and solute transport problems. c) Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems.</td>
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<td>Lecture notes</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1134 of 2667
This course aims at introducing the general procedures taken during an engineering geological site investigation. Students who complete the course should be able to design a site investigation program of measurements based on information from initial desk studies, and to analyse, integrate and interpret data from the measurement program.

In this course, students will gain hands-on experience performing laboratory and index tests commonly used in Rock and Soil Mechanics. Lecture notes will be available for download 1-2 days before each class.

In the Soil Mechanics Lab, the following seven laboratory tests are performed: Sieve Analysis, Hydrometer Analysis, Atterberg Limits, Proctor Compaction, (Direct Shear Test/Triaxial test), Falling Head Permeability and Consolidation Test. Through performing these tests, students gain an understanding of the relationship between index properties and soil behavior, as well as the strength, deformability and hydraulic characteristics of soils.

In the Rock Mechanics lab, the following laboratory tests are performed: Point load test, Brazilian tensile test, Uniaxial compression test, and Triaxial compression test. Through performing these experiments, students will get familiar with stress-strain curves, tensile, unconfined, and confined compressive strength of rocks, Young’s modulus and Poisson ratio, and finally cohesion and friction angle of intact rocks.

1. Introduction to groundwater problems. Concepts to quantify properties of aquifers.
2. Flow equation. The generalised Darcy law.
3. The water balance equation and basic concepts of poroelasticity.
5. Analytical solutions to flow problems
6. Finite difference scheme solution for simple flow problems.
10. Analytical solutions to transport problems.
11. Fractured and karst aquifers.
12. The unsaturated zone and capillary pressure.
13. Examples of applied hydrogeology from Switzerland and around the world. (Given by Dr. Beatrice Marti from hydrosolutions GmbH)
Literature

Online (ETH): http://www.icevirtuallibrary.com/content/book/100017


Supplemental literature will be suggested and made available during the course.

Prerequisites / notice
Students registering for the course confirm having read and accepted the terms and conditions for excursions and field courses of D-ERDW https://www.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/studium/exkursionen/AGB_ERDW_Exkursionen_en.pdf

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Engineering Geology: Integration
Courses for this Module take place in spring semester.

Engineering Geology: Industrial Internship

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<tbody>
<tr>
<td>651-4071-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>12 credits</td>
<td></td>
<td>external organisers</td>
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</table>

Prerequisites: successful participation in all 3 compulsory modules of the Major in Engineering Geology (Fundamentals, Methods and Integration).

The Industrial Internship of the Eng Geol Major takes place in the second MSc year after consultation with Dr. Heike Willenberg. Detailed regulations of this practical are published on the Engineering Geology Website.

Abstract

The industry practical is supervised both from the industry partner and ETH and consists of technically and/or scientifically challenging work in the engineering geology domain. The regular duration of the practical is 10 weeks. The practical is is pre-defined in a work plan and concluded with a report written by the student.

Objective

The goals of the industry practical are to become familiar with technical, economic, legal and communication issues of real-life work in private industry or technical administration.

Major in Geophysics

Compulsory Modules Geophysics

Geophysics: Methods I

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<tbody>
<tr>
<td>651-4005-00L</td>
<td>Geophysical Data Processing</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>C. V. Cauzzi, L. Ermert</td>
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</tbody>
</table>

Abstract

This course presents fundamental digital signal processing and filter theory with a focus on geophysical applications.

Objective

The goal of the course is to provide an understanding of the fundamental principles of digital signal processing and filter theory for application in geophysics and seismology. Form: two hours lecture and two hours of computer aided exercises per week.

Content
- Seismic station; noise; digitisation; the seismometer; Laplace transform; Z-Transform; digital filters design and application; inverse filters design and application; appendices (e.g., response spectra).

Lecture notes

Lecture notes will be made available for download from the website of the course.

Literature

The class follows no single book. A list of relevant texts will be given in class.

Prerequisites / notice

Assumed existing knowledge:
(a) time series, discrete systems, Fourier transform, Fourier and power spectra, convolution, correlation, stochastic time series (a course dealing with these topics is “Analysis of Time Series in Environmental Physics and Geophysics”);
(b) Python, Jupyter.

Students must bring their own laptop in class for computer exercises based on Python / Jupyter.
The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.

The course aims to provide the students with a general introduction of the fundamental concepts of fluid dynamics such as viscous flows, potential flows, instabilities. The course is a combination of lectures, exercises and demo experiments.

This course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.

**Numerical Modelling I and II: Theory and Applications**

**Lecturers:** J. A. R. Noir

**ECTS:**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
651-4001-00L | Introduction to Fluid Dynamics | W+ | 3 credits | 2G | J. A. R. Noir

**Abstract:**

This course aims to provide the students with a general introduction of the fundamental concepts of fluid dynamics such as viscous flows, potential flows, instabilities. The course is a combination of lectures, exercises and demo experiments.
Objective

The goal of this course is to introduce the students to some fundamental concepts of fluid dynamics, dimensional analysis and scaling laws. A particular attention is given to the assumptions and approximations underlying the derivations of the equations in various situations. The lectures are a mix of table top experiments, everyday observations and theoretical derivations.

Content

1) Fundamentals of fluid mechanics.
2) Ideal inviscid fluids.
3) Incompressible viscous fluids.
4) Heat transfer in fluids

Lecture notes

The slides of last year presentations will be made available at the beginning of the semester, they may be subject to changes during the lectures.

Literature


651-4007-00L

Continuum Mechanics

Abstract

In this course, students learn crucial partial differential equations (conservation laws) that are applicable to any continuum including the Earth's mantle, core, atmosphere and ocean. The course will provide step-by-step introduction into the mathematical structure, physical meaning and analytical solutions of the equations. The course has a particular focus on solid Earth applications.

Objective

The goal of this course is to learn and understand few principal partial differential equations (conservation laws) that are applicable for analysing and modelling of any continuum including the Earth's mantle, core, atmosphere and ocean. By the end of the course, students should be able to write, explain and analyse the equations and apply them for simple analytical cases. Numerical solving of these equations will be discussed in the Numerical Modelling I and II course running in parallel.

Content

A provisional week-by-week schedule (subject to change) is as follows:

Weeks 3,4: Density and gravity


Exercises: Computing density, thermal expansion and compressibility from an equation of state. Derivation of gravitational acceleration and its divergence from gravitational potential.

Weeks 5,6: Stress and strain


Exercises: Analysing strain rate tensor for solid body rotation. Computing stress invariants

Weeks 7,8: The momentum equation


Exercises: Deriving momentum equation. Computing velocity for magma flow in a channel.

Week 9: Viscous rheology of rocks

Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth's interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws.

Exercise: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

Weeks 10: The heat conservation equation


Exercises: Computing heat fluxes. Deriving equation for steady state temperature profile in a magmatic channel.

Week 11.12: Elasticity and plasticity


Exercise: Compute viscoelastic stress evolution.


Lecture notes

Script and Exam questions are available by request tgerya@ethz.ch

Literature


Competencies

Subject-specific Competencies

Concepts and Theories assessed

Method-specific Competencies

Analytical Competencies assessed

Problem-solving assessed

651-4130-00L

Mathematical Concepts in Geophysics

Abstract

The course guides students in learning the mathematical machinery used to solve various physical problems. Special attention is paid to the analytical methods to solve partial differential equations describing physical processes such as heat transfer, electromagnetic induction, wave propagation, among others.

Objective

The goal of this course is to refresh and deepen students' knowledge of mathematical methods relevant to the problems arising in solid Earth physics.
If you're interested in knowing more about the relationship between seismicity and plate tectonics, this is the course for you. (If you're not)

The provisional subjects covered in this course are as follows:

(i) Vectors, tensors, matrices, eigenvalue problems
(ii) Single-variable calculus
(iii) Vector calculus
(iv) Fourier analysis
(v) Partial Differential Equations
(vi) Special functions

Note: the actual content of the course may have slight deviations from the stated list.

Lecture notes

Current lecture notes and homeworks will be found during the course on the course Moodle page.

Literature

1. E. Kreyszig, "Advanced engineering mathematics"
2. M. Boas, "Mathematical methods in the physical sciences"
4. R. Sneider, "A guided tour of mathematical methods for the physical sciences"

<table>
<thead>
<tr>
<th>Course</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4014-00L</td>
<td>Seismic Waves II</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>T. Diehl, F. Lanza, A. Obermann</td>
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</tbody>
</table>

Abstract

This course provides an overview on the most widely used seismological methods to image the Earth's interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body-wave and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.

Objective

Understand the strengths and weaknesses of various active and passive tomographic methods to image the structure of the Earth.

Literature


Competencies

Subject-specific Competencies: Concepts and Theories fostered
Method-specific Competencies: Techniques and Technologies fostered
Personal Competencies: Creative Thinking fostered

Creative Thinking

This course provides an overview on the most widely used seismological methods to image the Earth's interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body-wave and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.

Objective

The aim of the course is to obtain a basic understanding of the physical process behind earthquakes and their basic mathematical description. By the conclusion of this course, we hope that you will be able to:
- describe the relationship between earthquakes and plate tectonics in a more sophisticated and complete way
- explain earthquake source representations of varying complexity;
- address earthquakes in the context of different tectonic settings;
- explain the statistical behaviour of global earthquakes
- describe and connect the ingredients for a seismotectonic study

Content

The course features a series of 14 meetings, in which we review some fundamentals of continuum mechanics and tensor analysis required for a complete understanding of the relation between earthquakes and plate tectonics. Our goal is to help you understand deformation from the small scale (fault) to the scale of plate tectonics. We will tell you about several ways to represent an earthquake source; we'll present these in order of increasing sophistication. You will enjoy (at least) a computer/class exercise and a guest lecture.

Topics covered in the course include:
- review of stress and deformation in the Earth, stress and strain tensors, rheology and failure criteria, fault stresses, friction and effects of fluids
- earthquake focal mechanisms; relationship between stress fields and focal mechanisms; seismic moment and moment tensors;
- crustal deformation from seismic, geologic, and geodetic observations;
- earthquake stress drop, scaling, and source parameters;
- global earthquake distribution; current global earthquake activity;
- different seismotectonic regions; examples of earthquake activity in different tectonic settings.

Lecture notes

Course notes will be made available on a designated course web site. Most of the topics discussed in the course are available in the book mentioned below.

Literature

Prerequisites / notice

Basic knowledge of continuum mechanics and rock mechanics, as well as notion of tensor analysis is strongly suggested. We recommend to have taken the course Continuum Mechanics (generally taught during the Fall semester).

This course will be taught in fall 2017 and it will be followed by Earthquakes 2: Source Physics in Spring 2018.

The course will be evaluated in a final written test covering the topics discussed during the lectures.

The course will be worth 3 credit points, and a satisfactory total grade (4 or better) is needed to obtain 3 ECTS.

The course will be given in English.

651-4021-00L Engineering Seismology

| Abstract | This course is a general introduction to the methods of seismic hazard analysis. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties. |
| Content | In the course it is explained how the disciplines of seismology, geology, strong-motion geophysics, and earthquake engineering contribute to the evaluation of seismic hazard. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties. The course includes the discussion related to Intensity and macroseismic scales, historical seismology and earthquake catalogues, ground motion parameters used in earthquake engineering, definitions of the seismic source, ground motion attenuation, site effects and microzonation, and the use of numerical tools to estimate ground motion parameters, both in a deterministic and probabilistic sense. |
| Lecture notes | Slides and scripts will be posted on Moodle. |
| Literature | It is recommended but not mandatory to buy one of these books:Planetary Sciences, 2nd edition, by Imke de Pater & Jack J. Lissauer (hardback), Cambridge University Press, 2015. Available free online from ETH’s network. |
| Prerequisites | Completion of “651-4130-00 Mathematical Methods” is required. |

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### Applied Geophysics

#### Applied Geophysics: Compulsory Courses

*The compulsory courses take place in spring semester.*

#### Applied Geophysics: Courses of Choice

*The compulsory courses take place in spring semester.*

### Major in Mineralogy and Geochemistry

#### Compulsory Module in Analytical Methods in Earth Sciences

*Students have to complete 6 credits in part A (microscopy courses), and 6 credits in part B (methods).*

### Microscopy Courses

*Compulsory Module in Analytical Methods in Earth Sciences: Microscopy Courses*

### Analytical Methods Courses

*Compulsory Module in Analytical Methods in Earth Sciences: Analytical Methods Courses*

### Restricted Choice Modules Mineralogy and Geochemistry

*A minimum of two restricted choice modules must be completed in the major Mineralogy and Geochemistry.*

### Mineralogy and Petrology

#### Mineralogy and Petrology: Compulsory Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>651-4028-00L</td>
<td>Physical Properties of Minerals</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>D. Huang, P. Saha, to be announced</td>
</tr>
<tr>
<td>Abstract</td>
<td>Physical properties of minerals, e.g. electrical properties, elastically properties are discussed. The effect of the crystal symmetry on the symmetry of physical properties as well as the mathematical formulation of the physical properties are major topics.</td>
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<tr>
<td>651-4039-00L</td>
<td>Thermodynamics Applied to Earth Materials</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>P. A. Sossi</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course develops the thermodynamic concepts necessary to predict phase equilibria and to compute chemical and physical properties from thermodynamic data in an Earth and planetary science context. Elementary concepts (1st and 2nd Laws; composition, state and extent); stability criteria; Legendre transforms; Maxwell relations and other manipulations of thermodynamic functions; calculation of Gibbs energy for pure solid, liquids and gases; simple solution models; order-disorder solution models; reciprocal solution models; equations of state for molecular fluids and real gases; free energy minimisation.</td>
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<tr>
<td>Objective</td>
<td>To provide students with the conceptual and practical skills necessary to implement thermodynamic models and data as provided in the Earth and planetary science literature.</td>
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<tr>
<td>Content</td>
<td>The course is neither an introduction to computer methods for calculating petrological phase equilibria nor an introduction to phase diagram methods.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The grade for the course is based on exercises assigned as homework. Some familiarity with elementary thermodynamics (phase rule, reactions) and mathematics (differentiation, integration) is assumed.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td></td>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>fostered</td>
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<td></td>
<td>Personal Competencies</td>
<td>Problem-solving</td>
<td>fostered</td>
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<td>Creative Thinking</td>
<td>fostered</td>
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<td>Critical Thinking</td>
<td>fostered</td>
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<td></td>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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</tbody>
</table>
Literature


Prerequisites / notice

The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.

Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential. Software will be provided for future use on own Laptop.

Competencies

<table>
<thead>
<tr>
<th>Competency</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
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<tr>
<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
<td>fostered</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<tr>
<td>Problem-solving</td>
<td>fostered</td>
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<tr>
<td>Project Management</td>
<td>fostered</td>
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<tr>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
<td>fostered</td>
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<td>Leadership and Responsibility</td>
<td>fostered</td>
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<tr>
<td>Adaptable and Flexibility</td>
<td>fostered</td>
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<tr>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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</table>

Objective

Students will gain an insight into cutting-edge research in planetary science and the geochemical evolution of Earth's mantle. The objective is to be able to synthesise scientific studies whose conclusions differ, and, eventually, to form a coherent opinion by debating and scrutinising the available data. This will be achieved by weekly lectures and exercises throughout the semester, culminating in a debate on a topical subject in Earth and planetary science.

Petrology and Volcanology

Petrology and Volcanology: Compulsory Courses

The compulsory courses take place in spring semester.

Petrology and Volcanology: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>651-4233-00L</td>
<td>Composition and Evolution of the Earth and Planets</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. A. Sossi, S. Flemetakis, E. Schettino, M. A. Thompson</td>
</tr>
</tbody>
</table>

Abstract

In this Masters-level course, we address the formation and evolution of the rocky planets with a particular focus on the chemical and isotopic make-up of the Earth and its mantle. This is achieved through analysis of its partial melting products in different tectonic settings and through time.

Objective

In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters.

Upon successful completion of this course students are able to:
- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data,
- communicate the results in a scientific report.

The competencies of system understanding, concept development, and measurement methods are taught and examined.

Content

Fundamental principles of X-ray diffraction
Setup and operation of X-ray diffractometers
Interpretation of powder diffraction data
Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

Lecture notes

Selected handouts will be made available in the lecture

Literature


Prerequisites / notice

The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.

Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential. Software will be provided for future use on own Laptop.
### Mineral Resources

#### Mineral Resources: Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
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<tr>
<td>651-4037-00L</td>
<td>Composition and Evolution of the Earth and Planets</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>C. Chelle-Michou, L. Tavazzani</td>
</tr>
</tbody>
</table>

**Abstract**
In this Masters-level course, we address the formation and evolution of the rocky planets with a particular focus on the chemical and isotopic make-up of the Earth and its mantle. This is achieved through analysis of its partial melting products in different tectonic settings and through time.

**Objective**
Students will gain an insight into cutting-edge research in planetary science and the geochemical evolution of Earth's mantle. The objective is to be able to synthesise scientific studies whose conclusions differ, and, eventually, to form a coherent opinion by debating and scrutinising the available data. This will be achieved by weekly lectures and exercises throughout the semester, culminating in a debate on a topical subject in Earth and planetary science.

#### Mineral Resources: Courses of Choice

<table>
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<th>Number</th>
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<tbody>
<tr>
<td>651-4069-00L</td>
<td>Fluid and Melt Inclusions: Theory and Practice</td>
<td>W</td>
<td>3 credits</td>
<td>3P</td>
<td>T. Driesner, L. Tavazzani</td>
</tr>
</tbody>
</table>

**Abstract**
Block course involving lectures, exercises and practical application of inclusion petrography, microthermometry, Raman and LA-ICPMS microanalysis.

**Objective**
Practical ability to carry out a meaningful fluid or melt inclusion study in the fields of geochemistry, petrology or resource geology, involving problem definition, research planning, quantitative measurements using a combination of techniques, critical interpretation and correct documentation of results.

**Lecture notes**
Handouts with extensive list of primary literature available.

**Literature**

**Data:** 02.07.2024 12:39
Introduction to computer tools for the simulation of hydrothermal processes: HYDROTHERM for fluid flow simulations, Geochemist's Workbench for thermodynamic modeling. While learning the respective computer programs is an essential part of the course, the emphasis will be on using these tools to learn how the physics and chemistry of hydrothermal system actually work.

Prerequisites / notice
This course is intended for earth science students; people interested but with a different background should contact the lecturer before signing up.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Media and Digital Technologies
Problem-solving

Social Competencies
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking

Resource Economics and Mineral Exploration

Does not take place this semester.

Abstract
Global mineral economics and the strategies of mineral exploration -- including geological, geochemical and geophysical methods, but also non-geological factors such as organisational, political and environmental aspects. Changing external lecturers.

Objective
Practical understanding of the procedure of exploring a mineral prospect, based on geological analysis, exploration by drilling, resource calculation of tonnage and grade as a basis for economic evaluation for reporting to investors.

Content
This block course will comprise 4 half-day lectures and a series of practical exercises from selection of a mineral property to discovery of mineral resources and their valuation. Teams are formed as Limited Partnership companies that have to select and bid for a mineral property offered during an auction. Each company has the same nominal budget. The highest bidder purchases the selected property, others need to purchase the remaining properties during an auction. Justification for selecting the property is justified in a report. The companies must interpret the geology of their mineral property to prepare a diamond drill program to discover and, eventually, delineate the mineral resources. This drill program is presented in a report prior to drilling. Drilling in the tri-dimensional matrix of the property is simulated using the software FOREUR, until budget lapse. The companies must select drill intervals for chemical analysis to document the extent and composition of the discovered mineralization. Portions of the mineral rights can be traded for capital between the companies. An estimate of the tonnage and grade of the discovered resource is prepared using geometric methods and GIS software (ex. Arc GIS). The ground value of the resource is estimated by a computation of the Net Smelter Return at current metal prices. The results of the exploration program are presented in a comprehensive report.

Lecture notes
Handouts for background information and a computer simulation program for the case-study exercise will be provided. Participants must bring a Windows-based laptop computer. Prerequisites: Knowledge of mineral deposit-type characteristics is useful (orogenic gold, Cu-Zn VMS, Ni-Cu-PGE); at least "Integrierte Erdsysteme", "Ore Deposit 1", or adequate knowledge of mineral deposits acquired by preparatory reading. Basic knowledge of ArcGIS software is important to produce maps and sections required in reports. Training exercises and tutorials will be provided in advance to prepare for the course. Taught biennially in collaboration with University of Geneva.

This course is co-organised by ETH Zurich (Prof. C. Chelle-Michou) and University of Geneva (Prof. R. Moritz)

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Social Competencies
Communication

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking

Literature

Geochemistry: Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>651-4049-00L</td>
<td>Conceptual and Quantitative Methods in Geochemistry</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>G. De Souza, J. B. Peters, J.-C. Storck</td>
</tr>
</tbody>
</table>
Prerequisite: Successful completion of the BSc-course "Geochemistry" (651-3400-00L).

Abstract
This course will introduce some of the main quantitative methods available for the quantitative treatment of geochemical data, as well as the main modelling tools. Emphasis will both be on conceptual understanding of these methods as well as on their practical application, using key software packages to analyse real geochemical datasets.

Objective
Development of a basic knowledge and understanding of the main tools available for the quantitative analysis of geochemical data.

Content
The following approaches will be discussed in detail: major and trace element modelling of magmas, with application to igneous systems; methods and statistics for calculation of isochrons and model ages; reservoir dynamics and modelling of ocean (biogeo)chemistry.

We will discuss how these methods are applied in a range of Earth Science fields, from cosmochemistry, through mantle and crustal geochemistry, volcanology and igneous petrology, to chemical oceanography.

A special emphasis will be put on dealing with geochemical problems through modeling. Where relevant, software packages will be introduced and applied to real geochemical data.

Lecture notes
Slides of lectures will be available.

Pre-requisites / notice
Pre-requisite: Geochemie I and II

Competencies
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<th>Social Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
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<td>Techniques and Technologies</td>
<td>Media and Digital Technologies</td>
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651-4227-00L Planetary Sciences: a Chemical Perspective

Abstract
Formation and evolution of the solar system and its planets from a geochemical perspective

Objective
To understand the formation and evolution of the solar system and its planets from a geochemical perspective

Content
The Sun and solid objects in the solar system (planets, comets, asteroids, meteorites, interplanetary dust) are discussed from a geochemical perspective. What does their present-day composition tell us about the origin, formation and evolution of the solar system? The lectures introduce the basics of the terrestrial and giant planets, comets and asteroids, gained from modern space missions and the study of extraterrestrial materials. The chemical and isotopic composition of meteorites, being the most primitive material available for study, is a further major topic.

Lecture notes
Slides and additional materials are available electronically

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Geochemistry: Courses of Choice

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<tr>
<td>651-4233-00L Composition and Evolution of the Earth and Planets</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>P. A. Sossi, S. Flemetakis, E. Schettino, M. A. Thompson</td>
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Abstract
In this Masters-level course, we address the formation and evolution of the rocky planets with a particular focus on the chemical and isotopic make-up of the Earth and its mantle. This is achieved through analysis of its partial melting products in different tectonic settings and through time.

Objective
Students will gain an insight into cutting-edge research in planetary science and the geochemical evolution of Earth's mantle. The objective is to be able to synthesise scientific studies whose conclusions differ, and, eventually, to form a coherent opinion by debating and scrutinising the available data. This will be achieved by weekly lectures and exercises throughout the semester, culminating in a debate on a topical subject in Earth and planetary science.

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<tr>
<td>651-4057-00L Climate History and Palaeoclimatology</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>H. Stoll, I. Hernández Almeida</td>
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Abstract
Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

Objective
The student will be able to describe the natural factors that lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes.

Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.
The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is there evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?
2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?
3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?
4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?
5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

### Competencies

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### Literature

Will be identified based on the chosen topic.

### Literature

- **651-4225-00L** Topics in Geochemistry
  - **Abstract**: In this course we present and discuss advanced topics in geochemistry based on the critical reading of research papers. Themes include hydrothermal geochemistry, isotopes in meteorites, low temperature geochemistry and biogeochemistry.
  - **Objective**: The goal of the course is discuss topics in advanced geochemistry which were not covered in other general and specialized geochemistry courses. In addition, we aim at training the student's ability to critically evaluate research papers and to summarize the findings concisely in an oral presentation.
  - **Lecture notes**: None
  - **Literature**: Will be identified based on the chosen topic.

- **651-4010-00L** Planetary Sciences: a Physical Perspective
  - **Abstract**: This course aims to give a physical understanding of the formation, structure, dynamics and evolution of planetary bodies in our solar system and also apply it to ongoing discoveries regarding planets around other stars.
  - **Objective**: The goal of this course is to enable students to understand current knowledge and uncertainties regarding the formation, structure, dynamics and evolution of planets and moons in our solar system, as well as ongoing discoveries regarding planets around other stars. Students will practice making quantitative calculations relevant to various aspects of these topics through weekly homeworks.
  - **Lecture notes**: Slides and scripts will be posted on Moodle.
  - **Literature**: It is recommended but not mandatory to buy one of these books:
  - **Competencies**:
    - **Subject-specific Competencies**
      - Concepts and Theories: assessed
      - Techniques and Technologies: assessed
    - **Method-specific Competencies**
      - Analytical Competencies: assessed
      - Adaptability and Flexibility: assessed
      - Creative Thinking: assessed
      - Critical Thinking: assessed
    - **Personal Competencies**
      - Creative Thinking: assessed
      - Critical Thinking: assessed

### Literature

- **651-4229-00L** Advanced Geochronology
  - **Abstract**: The course is designed to introduce students to the principles of geochronology, focusing on the use of isotopic and chemical systems as tools for dating and understanding the Earth's history. Students will learn about the fundamental principles of radiometric dating, the decay of radioactive isotopes, and the interpretation of geochronological data.
  - **Objective**: The primary objective of this course is to provide students with a comprehensive understanding of the principles and applications of geochronology. Students will learn how to measure and interpret geochronological data, including the use of different isotopic systems and techniques.
  - **Content**: The course will cover a range of topics, including the basics of radioactive decay, the use of stable and radiogenic isotopes, and the application of geochronological techniques to various geological problems. Students will also learn about the pitfalls and uncertainties associated with geochronological data.
  - **Lecture notes**: Slides and scripts will be posted on Moodle.
  - **Literature**: It is recommended but not mandatory to buy one of these books:
This lecture gives an overview of methods and applications of geochronology across a wide range of Earth Science disciplines. Several in their field specialized lecturers cover the principles and methods and will give insight into recent applications and research projects.

**Objective**

The purpose of this lecture is to provide a comprehensive overview of:

a) the different radiometric methods in Geology, the different dating tasks and the constraints put by the complexity of natural systems, including dating by cosmogenic nuclides,

b) the various analytical tools available today for radiometric dating, their advantages and disadvantages,

c) the use of noble gases in Geochemistry and
d) detailed description of case studies, as examples of approach of a number of geological problems and interpretation of the data.

At the end students know the different isotope systems, methods and their application. Understand literature and critical reading and interpretation of published data is possible. For simple geochronological questions they can describe a scientific approach and possible solution. They can plot and interpret data using IsoplotR for different applications.

**Content**

1. Introduction and overview, Data visualization and statistics in IsoplotR, Principles of U-Pb geochronology
2. In situ U-Pb geochronology 1 (LA-ICPMS/SIMS principles, zircon)
3. In situ U-Pb geochronology 2 (calcite, garnet, other minerals)
4. High-precision ID-TIMS U-Pb geochronology (principles and applications)
5. High-precision U-series geochronology (carbonates, silicates)
6. In situ U-series geochronology (zircon, garnet etc.)
7. K-Ar and 40Ar/39Ar geochronology , Principles and Applications
8. Fission Track dating
9. U-Th/He dating
10. Thermochronology applications/lab visit
11. Noble gases - basics, reservoirs, geo/cosmochem. applications: mainly chronology
12. Cosmogenic nuclides (stable and radionuclides) - basics, geo/cosmochem. applications, C14

**Lecture notes**

Script (for part of the lecture), partly power point presentations (in the web)

**Literature**

http://elements.magazine.org/get_pdf.php?fn=e9_1.pdf&dr=e9_1

- Geochronology and Thermochronology
  - Author(s): Peter W. Reiners
  - Richard Carlson
  - Paul R. Renne
  - Kari M. Cooper
  - Darryl E. Granger
  - Noah M. McLean
  - Blair Schoene
  - First published: 8 January 2018


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**Open Choice Modules**

**Modules from the Geology Major**

**Restricted Choice Modules from Geology**

**Modules of Choice from Geology**

**Modules from the Geophysics Major**

**Restricted Choice Modules Geophysics**

**Modules from the Engineering Geology Major**

**Restricted Choice Module from Mineralogy and Geochemistry**

**Modules of Choice from Mineralogy and Geochemistry**

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**Electives**

Courses can be chosen from the complete offerings of the ETH Zurich and University of Zurich (according to prior agreement with the subject advisor).

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<td>651-0048-00L</td>
<td>Electron Microprobe Course 2 - Practice</td>
<td>W Dr</td>
<td>1</td>
<td>2</td>
<td>J. Allaz</td>
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**Abstract**


**Objective**

Ability to operate the Electron Microprobe with minimal assistance, optimise the analysis setup in order to obtain excellent results, identify possible source of error (troubleshooting) and fix them, data treatment (and interpretation).

**Content**

Physical principles of electron optics, interaction of electrons with matter, production of X-rays, interaction of X-rays with matter. Detection of X-rays. Laboratory work in the field of Earth sciences.

**Lecture notes**

Script and User Manual will be provided.


**Prerequisites / notice**

- 4 full days.
- Prerequisite: Analytical methods in Petrology and Geology (651-4055-00L) and 651-0046-00 Electron Microprobe Course 1 - Theory

- Restricted attendance, max. 8 students (incl. Doctoral students and external participants). Contact J. Allaz.
Subject-specific Competencies

Method-specific Competencies

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| 327-0703-00L | Electron Microscopy in Material Science | W 4 credits 2V+2U | S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze |

Abstract

A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective

This course provides a general introduction into electron- and ion-microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, focused ion-beam and atom probe microscopes are presented. Throughout the semester, various applications in materials science, solid state physics, structural biology, structural geology, and structural chemistry will be reported.

Lecture notes will be distributed in English.

Literature


Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)


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| 651-3541-00L | Exploration and Environmental Geophysics | W 4 credits 3V | P. Edme, H. Maurer, A. Shakas |

Abstract

Overview and understanding of the most important geophysical methods: Potential field methods (Gravimetrics and Magnetics), Electrical and electromagnetic methods, Refraction and reflection seismics, Georadar. Discussion of survey design, sources and receivers and data processing.

Objective

Overview and understanding of the most important geophysical methods. Proposed solutions to assess and observe problems relevant to exploration and environmental geophysics in soil, ice and lithosphere at different scales. Getting familiar with measuring- and interpretation procedures. Pointing out the possibilities and limitations of geophysical methods.

Content


Lecture notes

Available through Moodle / eDoz.

Additional material will be provided by the lecturers.

Literature


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| 651-4086-00L | Experimental Methods in Petrology | W 3 credits 2P | C. Liebske, N. Küter |

Abstract

This course introduces the most common experimental methods employed in petrology. Such methods can be used to determine thermodynamic data, physical properties and phase equilibria of minerals, magmas and fluids. The course consists of about 1/3 theory combined with 2/3 hands-on lab-work to demonstrate how experiments are performed in practice.

Objective

The principal goal is to gain knowledge on experimental techniques, and on the principle setup to obtain quantitative data on e.g. phase relations, thermodynamic, kinetic and rheological properties of Earth materials. At the end of the course, participants should be able to evaluate experimental data independently, and design appropriate experiments on their own.
Among other aspects 'Experimental methods in petrology' covers the following subjects:

(1) Introduction and historical development of experimental petrology.
(2) Experimental methods at ambient pressure (1 bar) with practical exercise to determine basic thermodynamic data.
(3) Starting and capsule materials; techniques to buffer chemical activities.
(4) Experimental methods at moderate pressures: externally and internally heated gas-pressure devices.
(5) High-pressure solid-media experimental techniques (piston cylinders).
(7) Evaluation of petrologic experiments (preparation of run products, analytical and spectroscopic methods of examination and quantification).

The experiments performed during lab-work will be evaluated in the context of a small research project, which is introduced during the course.

Lecture notes
A summary of the material presented in the lectures is distributed weekly.

Prerequisites / notice
This course is aimed at MSc and PhD students, who are interested in experimental methods. No foreknowledge on this is required but basic understanding of petrology and chemical thermodynamics is expected.

651-4114-00L Illustrations in Natural History (University of Zürich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: BIO271

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract
The general introduction to scientific graphics is followed by explanations and practical exercises with the use of important techniques of drawing: line drawing, hatching, stippling, shading with ink and pencil. Fossils and recent organisms serve as models. In addition basic knowledge in digital image processing will be taught (Photoshop).

Objective
By the end of the module, students are able to
- apply the most important conventional drawing techniques
- use PhotoShop or GIMP
- communicate scientific information in clearly designed illustrations using these techniques

651-4273-00L Numerical Modelling in Fortran

This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

Objective
Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

Competencies
- Subject-specific Competencies: Techniques and Technologies
- Method-specific Competencies: Media and Digital Technologies

651-1392-00L Palaeontological Colloquium (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: BIOS71

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract
Talks and discussion on current topics in Palaeontology (Palaeobotany, Palaeozoology and Micropalaeontology).

651-4101-00L Physics of Glaciers

Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1149 of 2667
Objective
After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

Content
The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Lecture notes
Will be provided on Moodle

Literature
A list of relevant literature is available on Moodle

Prerequisites /
High-school mathematics and physics knowledge required.

Competencies

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651-0254-00L
Seminar Geochemistry and Petrology
E- 0 credits 2S

Objective
Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

Content
Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschafter, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

651-1692-00L
Seminar in Applied and Environmental Geophysics
E- 0 credits 1S

Objective
Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.

Content
Numerical analysis methods in tunnelling. Conventional excavation methods (full face, top heading and bench, side drift method, ...)

Lecture notes
Autographieblätter

Literature
Empfehlungen

Prerequisites /
This course will continue to be offered in German up to and including HS24.

Competencies

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651-1091-00L
Colloquium Department Earth and Planetary Sciences
E- Dr 0 credits 1K

Objective
Invited speakers from the entire range of Earth Sciences. Selected themes in sedimentology, tectonics, palaeontology, geophysics, geochemistry, mineralogy, paleoclimate and engineering geology on a regional and global scale.

Content
According to variable program.

Lecture notes
No

Literature
No

651-2613-00L
Human Geography III (Geographies of Difference)
(Universität Zürich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO232

Recommended prerequisite: Human Geography II (UZH Module Code: GEO122)

Mind the enrolment deadlines at UZH:

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1150 of 2667
This course enables students to think through and about difference geographically: multi-scalar, critically, spatially. Students learn to understand selected theoretical perspectives in human geography.

- To understand selected theoretical perspectives in human geography that problematize questions of difference; — To use these theoretical perspectives to interpret empirical phenomena of social difference and inequality and raise questions about them. — To deepen knowledge on empirical phenomena of social difference in one specific topic of human geography. — To write a seminar paper, using theoretical and empirical material.

Following an introductory lecture, students will split into four smaller seminar groups, focused on different thematic areas from urban, political and economic geography. Seminars will be based on a close reading of selected material and designed for interactive participation and discussion.

Each seminar consists of theory-oriented sessions, where students will gather first insights into selected theoretical perspectives of human geography; Using these perspectives, students develop their knowledge of each seminar group’s thematic area of focus and practice applying theory to empirical fields of research.

After the introductory lecture in week 1, students must enroll in one of four seminar groups via OLAT. Attendance of the introductory lecture is a prerequisite for participation in the first group session.

### 651-2601-00L Human Geography I: One Earth - Many Worlds (University of Zurich)

- **W 5 credits 2V+2U**
- University lecturers

**Abstract**

Mind the enrolment deadlines at UZH:

**Objective**

You will learn the basics of physical geography and apply some of these exercises to the lectures.

- You know the basics of physical geography and can use its definitions and technical terms correctly.
- You will acquire the physical-geographical background of current problems (climate change, erosion,...).
- You know the basics of scientific work in human geography and can apply them in a small project. 

**Lecture notes**

PowerPoint-slides (German)

**Literature**


### 651-4088-03L Physical Geography III (Geomorphology and Glaciology) (University of Zurich)

- **W 5 credits 1V+1U**
- University lecturers

**Abstract**

Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufs. Dabei werden einzelne Wasserressourcen (Schnee, Boden und Grundwasser) und Flüsse zwischen den Speichern (Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.

**Objective**

You will learn the basics of physical geography and apply some of these exercises to the lectures.

- You know the basics of physical geography and can use its definitions and technical terms correctly.
- You acquire the physical-geographical background of current problems (climate change, erosion,...).
- You know the basics of scientific work in human geography and can apply them in a small project.

**Lecture notes**

PowerPoint-slides (German)

**Literature**


### 651-4088-01L Physical Geography I (Basics and Spheres) (University of Zurich)

- **W 5 credits 2V+2U**
- University lecturers

**Abstract**

Mind the enrolment deadlines at UZH:

**Objective**

- You will learn the basics of physical geography and apply some of these exercises to the lectures.
- You know the basics of physical geography and can use its definitions and technical terms correctly.
- You acquire the physical-geographical background of current problems (climate change, erosion,...).
- You will apply the principles of scientific work (analysis, interpretation, written summary).

### 651-1617-00L Geophysical Fluid Dynamics and Numerical Modelling Seminar

- **E-Dr 0 credits 1S**
- P. Tackley, T. Gerya

**Abstract**

Heat and mass transfers from the mantle to the crust control many aspects of the differentiation of our planet, including (1) primitive melt chemistry, (2) layering of the crust, (3) type of volcanic eruption, (4) formation of mineral deposits. This year, we will focus on processes in crystal mushes (formation, crystallization, remobilization, degassing).

**Objective**

This class will allow the students to learn about the modern methods and ideas on heat and mass transfers in magmatology through classic and recently published papers.

- Communication of scientific results to the scientific community and the public is critical. In the class, the students will read and analyse scientific papers and discuss them orally to the class. The students will also create a Wikipedia page and reformulate scientific results for the public.

**Content**

The class will focus mostly on 1) reading literature on topics of interests, 2) oral and written presentations of the papers, 3) exercises illustrating the topic, to allow students to work by themselves on some well-defined problems. 

### 651-1091-02L Geological Colloquium

- **E-Dr 0 credits 2K**
- S. Bernasconi
This blended learning course will provide an overview of cosmogenic and anthropogenic radionuclides, powerful tools for understanding a...
Each lecture period will consist of a presentation and discussion—to be led by 1-2 students (depending on class size)—covering a given topic. Lecturers will foster subject-specific competencies through active learning and hands-on exercises. The semester research project is determined by student and supervisor. The topic of each project is unique and not related to the BSc or MSc Thesis. The project must be approved in advance by the study advisor. Only one project (small or large) is allowed per study degree.

651-4145-00L Seminar on Precambrian Geobiology and Biogeochmical Cycles

Abstract
The Precambrian Earth experienced several environmental states—all drastically different from today—that are recorded in sedimentological, fossil, and genetic records. We will review "classic" and recent scientific literature on the evolution of chemical and biological processes to critically evaluate what we do and don't know about how our planet's biogeochemistry has changed through time.

Objective
For decades, researchers have attempted to reconstruct Precambrian environmental states and their relative timing using tracers recorded in the sedimentological, fossil, and genetic records. Here, by reading and discussing "classic" and more recently published scientific papers, students will learn about influential discoveries related to Earth history within the fields of geobiology and geochemistry.

In completing the course, students will specifically learn:

- Why Earth's surface chemical composition evolved from anoxic to oxic environments
- How life evolved from simple prokaryotic metabolisms to multicellular eukaryotes
- The importance of geological, chemical, and biological feedback mechanisms
- How to discern between biologic innovation and environmental importance
- How to summarize, interpret, and discuss current evidence for what is and isn’t known about Earth's biogeochemical evolution
- How to assess opposing scientific viewpoints and outstanding questions in the literature

Content
Each lecture period will consist of a presentation and discussion—to be led by 1-2 students (depending on class size)—covering a given paper or set of papers. All students are expected to read the relevant papers before class and come prepared for discussion. Lecture periods will be divided between "review" presentations aimed at introducing the background and fundamentals of each topic and "debate" or "comparison"-style presentations, in which two (sometimes opposing) views of a given topic will be discussed and assessed.

Lecture notes
Where available, presentations and notes will be provided online during the course.

Literature
All required and recommended scientific publications will be provided online during the course.

Competencies
Subject-specific Competencies

| Concepts and Theories | fostered |
| Techniques and Technologies | fostered |

Social Competencies
Communication fostered

Personal Competencies
Creative Thinking fostered

Critical Thinking fostered

651-4147-00L Fracture Mechanics

Abstract
The course provides an introduction to the concepts of fracture mechanics and its application to the Earth's crust. Theoretical concepts, practical applications, and computational methods are covered. The course has a particular focus on solid Earth applications.

Objective
To acquire the theoretical background of fracture mechanics and to be able to apply them to the solution of relevant problems in geosciences.

Content
5. Additional: dynamic (inertial) effects, fracture and breakdown energy, coupling between elastodynamics and shear heating, computational methods in fracture mechanics.

Prerequisites / notice
Lecture notes and relevant reading materials will be provided. Students are encouraged to take their own notes.

651-2002-00L Semester Research Project (large)

Abstract
Small individual research project supervised by a lecturer of D-ERDW that builds on the skills acquired during the BSc or MSc studies. The project consists of research activity in a selected scientific topic aimed at producing new scientific results and/or data.

Objective
Students deepen their knowledge in a specific topic. They familiarize with research procedures and scientific methods that are used in current research. They gain experience in writing scientific reports/papers.

Content
The content of the project consists of research activity aimed at producing new scientific results and/or data. It does not reduce to literature work.

Prerequisites / notice
The project must be approved in advance by the study advisor.

The semester research project is determined by student and supervisor. The topic of each project is unique and not related to the BSc or MSc Thesis. Only one project (small or large) is allowed per study degree.

402-0368-07L Lecture Series: Space Research and Exploration

Abstract
Lecture Series about selected topics of space research and exploration consisting of individual talks given by different leading experts from academia and industry.

Objective
Attending students will:
- experience the interdisciplinarity of space research and exploration spanning physics, engineering, geosciences, biology and more
- get familiar with the Swiss space research and industry landscape
- enhance their communication skills by broadening their research horizon
- have the opportunity for direct learning by posing questions to experts
The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay between the scientifically desirable and the technologically possible. The ‘Lecture Series: Space Research and Exploration’ aims to shed light on key questions engaged by leading scientists and engineers today. It consists of weekly lectures, given by different speakers with vast experience in their respective field (e.g., Human Spaceflight, System Engineering of Spacecraft, Space Life Sciences, Space-based astrophysics). Subsequent to the talk, the student will have the opportunity to deepen their understanding by asking questions to the presenter in a moderated Q&A.

Confirmed speakers will be announced by the start of the semester (see lecture from last year for previous speakers).
Content

The course consists of 9 sections, each constituting one 2-hour class:

1. Introduction and overview
2. Formation and differentiation of terrestrial planets
3. Primary Crusts: Required but rarely observed
4. Secondary Crusts: The ubiquitous but diverse planetary crust
5. Tertiary Crusts: Is Earth's continental crust the only example?
6. Icy Crusts: Just special cases?
7. Crustal evolution: Is diverse as the crusts themselves
8. Looking for unifying themes: Are there more variables than planetary bodies?
9. Exoplanets: Lessons from (or for?) our solar system

Prerequisites / notice

The course will be organised in the form of 9x2 hour lectures. The course will be either pass or fail based on performance in take-home exercises, written assignments and in-class participation.

101-0307-00L Design and Construction in Geotechnical Engineering W 4 credits 3G I. Anastasopoulos, K. Kassas, A. Marin, L. Sakellariadis

Abstract

This lecture deals with the practical application of the knowledge gained in the fundamental lectures from the Bachelor degree. The basics of planning and design of geotechnical structures will be taught for the main topics geotechnical engineers are faced to in practice.

Objective

Transfer of the fundamental knowledge taught in the Bachelor degree to practical application.

Ability to plan and design geotechnical structures based on the state of the art.

Content

Introduction to Swisscode SIA
Foundations and settlements
Pile foundations
Excavations
Soil nailing
Reinforced geosystems
Ground improvement
River levees

Lecture notes

Script in the form of chapters and powerpoint overheads with web support (moodle-app2.let.ethz.ch)
Exercises

Literature

Relevant literature will be stated during the lectures

Prerequisites / notice

Pre-condition: Successful examinations (pass) in the geotechnical studies (soil mechanics and ground engineering, each 5 credits) in the Bachelor degree of Civil Engineering (ETH), or equivalent for new students.

The lecture contains at least one presentation from practice.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Choice of courses from the complete offerings in Earth Sciences MSc

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ERDW

Master's Project Proposal

Number Title Type ECTS Hours Lecturers

651-4060-00L MSc Project Proposal O 10 credits 21A Lecturers

Abstract

The introductory lecture on conduct as a scientist is an integral part of the course.

Objective

The main purpose of the Master Project Proposal is to help students organize ideas, material and objectives for their Master Thesis, and to begin development of communication skills.

The main objectives of the Master Project Proposal are to demonstrate the following abilities:
- to formulate a scientific question
- to present scientific approach to solve the problem
- to interpret, discuss and communicate scientific results in written form
- to gain experience in writing a scientific proposal
### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4062-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme;
- c. have successfully completed the MSc Project Proposal

**Abstract**

The master programme will be completed by a master thesis on a topic selected from the subject range of the chosen major programme.

**Objective**

Students are to prove their skills in working autonomously on a scientific project. They document their work in a scientific report.

### Course Units for Additional Admission Requirements

**The courses below are only available for MSc students with additional admission requirements.**

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-3400-AAL</td>
<td>Fundamentals of Geochemistry</td>
<td>E-</td>
<td>6 credits</td>
<td>13R</td>
<td>C. Liebske, P. A. Sossi</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Self-study course. This course is only available for those who got it as an additional requirement in their MSc admission.

**Objective**

The course is intended to let the student learn fundamentals of geochemistry that were found lacking in his/her studies prior to entering the MSc in Earth Sciences at ETH. Contents of the course will be defined based on text books and/or scientific papers.

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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>406-0243-AAL</td>
<td>Analysis I and II</td>
<td>E-</td>
<td>14 credits</td>
<td>30R</td>
<td>M. Akveld</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Mathematical tools for the engineer

**Objective**

Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers.

**Content**

- Complex numbers.
- Calculus for functions of one variable with applications.
- Simple Mathematical models in engineering.

**Literature**

- Textbooks in English:

- Textbooks in German:
  - M. Akveld, R. Sperb: Analysis I, vdf
  - M. Akveld, R. Sperb: Analysis II, vdf
  - L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
  - L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

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</tr>
</thead>
<tbody>
<tr>
<td>406-0062-AAL</td>
<td>Physics I</td>
<td>E-</td>
<td>5 credits</td>
<td>11R</td>
<td>A. Vaterlaus</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

**Objective**

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts in mechanics.

**Content**


  Chapters:
  - 1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

**Literature**

- Friedhelm Kuypers: Physik für Ingenieure und Naturwissenschaftler
- Band 1: Mechanik und Thermodynamik
- Wiley-VCH Verlag, 2002
- 4th edition 2022

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered
- Method-specific Competencies
  - Analytical Competencies: fostered
  - Problem-solving: assessed
- Personal Competencies
  - Self-direction and Self-management: fostered

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<tbody>
<tr>
<td>651-3521-AAL</td>
<td>Tectonics</td>
<td>E-</td>
<td>3 credits</td>
<td>6R</td>
<td>T. Gerya, W. Behr</td>
</tr>
</tbody>
</table>

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Wiley-VCH Verlag, 2002
4th edition 2022
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Comprehensive understanding of role and evolution of oceanic and continental lithosphere in global plate tectonics and evolution of earth. Understanding principles of theoretical and experimental geothermics and fundamentals of mantle and lithosphere rheologies.

Objective
Comprehensive understanding of role and evolution of oceanic and continental lithosphere in global plate tectonics and evolution of earth. Understanding principles of theoretical and experimental geothermics and fundamentals of mantle and lithosphere rheologies.

Content

Lecture notes
Detailed scriptum in digital form and additional learning modules (www.lead.ethz.ch) available on intranet.

Literature
see list in scriptum.

Prerequisites / notice
PPT-files of each lecture may be played back for rehearsal on www.lead.ethz.ch.

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529-2001-AAL
Chemistry I and II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Chemistry I and II: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium, kinetics, acids and bases, electrochemistry

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

Lecture notes
Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

Literature
Housecroft and Constable, CHEMISTRY
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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406-0603-AAL
Stochastics (Probability and Statistics)
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid foundation in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

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The course is self taught and covers the following topics of fundamentals in geophysics:

**Fundamentals in Geophysics II: Dynamics of the Earth**

*Concepts and Theories*

- Paleomagnetism
- Geodesy
- Gravimetry
- Tomography
- Seismology

*Media and Digital Technologies*

*Analytical Competencies*

*Problem-solving*

*Self-direction and Self-management*

- Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.


- Personal Competencies

- Method-specific Competencies

- Literature

- From "Introductory Statistics with R (online)" by Peter Dalgaard; ISBN 978-0-387-79054-1; DOI: 10.1007/978-0-387-79053-4

*From within the ETH, this book is freely available online under:

- "Introductory Statistics with R" by S. Dowdy et al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435

*From within the ETH, this book is freely available online under:
http://www.springerlink.com/content/m17578/

- From "Introductory Statistics with R" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435

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*E* 4 credits 6R  L. de Palézieux dit Falconnet

**651-3525-AAL Introduction to Engineering Geology**

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*

*Abstract*

This introductory course starts from a descriptions of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally practical aspects of ground engineering, including tunneling and landslide hazards are presented.

*Objective*

Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.

*Content*


*Lecture notes*

Lecture Material as defined in German PPT Slides of the German Course “651-3525-00L Ingenieurgeologie”.

*Moodle Course Materials available.*

*Literature*

For English speakers study chapters 1-3 of Part I of the book “Geological Engineering” (Gonzalez de Vallejo & Ferrer 2011, CRC Press), without groundwater flow, consolidation time, geophysical methods, details of triaxial tests in soils and rocks, details of clay mineralogy.

*Prerequisites / notice*

Participate on all exercises of “651-3525-00L Ingenieurgeologie”, Tuesday 13-14 pm.

Participate in Written Exam together with students of the German Course

**651-3051-AAL Fundamentals in Geophysics I: Structure and evolution of the Earth**

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*

*Abstract*

The course is self taught and covers the following topics of fundamentals in geophysics:

- Seismology
- Tomography
- Gravimetry
- Geodesy
- Paleomagnetism

*Objective*

The course is an admission requirement given to students lacking fundamentals in geophysics related to the structure and evolution of the planet Earth. It will allow the student to acquire the necessary knowledge to pursue a Master in Geophysics, the student will learn the basics of seismology, tomography, gravimetry, geodesy and paleomagnetism and how these can be used to constrain the structure and evolution of the Earth.

*Content*

The course is based on the book “Fundamentals in Geophysics” 3rd edition by W. Lowrie available online from the ETH library. The list of chapters to read will be determined in an initial individual meeting with the student.

*Prerequisites / notice*

Enrolment ONLY for MSc students with an additional admission requirement.

*Any other students (e.g. incoming exchange students, doctoral students) CANNOT enroll for this course unit.*

**651-3052-AAL Fundamentals in Geophysics II: Dynamics of the Earth**

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*

*Any other students (e.g. incoming exchange students, doctoral students) CANNOT enroll for this course unit.*
Abstract
The course is self-taught and covers the following topics of fundamentals in geophysics:
- Mantle dynamics
- Plate tectonics
- Core dynamics
- Earth's magnetic field
- Earth's rotation

Objective
The course is an admission requirement given to students lacking fundamentals in geophysics related to the structure and evolution of the planet Earth. It will allow the student to acquire the necessary knowledge to pursue a Master in Geophysics, the student will learn the basics of seismology, tomography, gravimetry, geodesy and paleomagnetism and how these can be used to constrain the structure and evolution of the Earth.

Content
The course is based on the book "Fundamentals in Geophysics" 3rd edition by W. Lowrie available online from the ETH library and from the Treatise of geophysics available online. The list of chapters to read will be determined in an initial individual meeting with the student.

Prerequisites / notice
Enrollment ONLY for MSc students with an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enroll for this course unit.

<table>
<thead>
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<th>Credits</th>
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<tbody>
<tr>
<td>651-3071-AAL</td>
<td>Fundamentals of Geology I: Earth’s Interior</td>
<td>3</td>
<td>R</td>
<td>V. Picotti, W. Behr</td>
</tr>
</tbody>
</table>

Abstract
The Planet Earth, its interior and the plate tectonics as unifying theory. The rock cycle and the minerals and rocks. Igneous, Metamorphic and Sedimentary rocks. Deformation and earthquakes. Exploration of the earth interior.

Objective
Understanding the Earth System and the multi-disciplinary approach to the Earth Sciences. Framing the various minerals and rocks into plate tectonics and the rock cycle. Discussing the main tools for exploring the earth interior and understanding the deformation of rocks at various depths. Earthquakes and volcanoes and associated danger.
Chapters 1, 2, 3, 4, 5, 6, 7, 8, 10 and 11 of the Book: Understanding Earth (8th Edition, 2020), By John Grotzinger and Thomas Jordan.

CH 1 THE EARTH SYSTEM
The Scientific Method
Geology as a Science
Earth’s Shape and Surface
Peeling the Onion: Discovery of a Layered Earth
Earth as a System of Interacting Components
An Overview of Geologic Time

CH 2 PLATE TECTONICS: THE UNIFYING THEORY
The Discovery of Plate Tectonics
The Plates and Their Boundaries
Rates and History of Plate Movements
The Grand Reconstruction
Mantle Convection: The Engine of Plate Tectonics
The Theory of Plate Tectonics and the Scientific Method

CH 3 EARTH MATERIALS: MINERALS AND ROCKS
What Are Minerals?
The Structure of Matter
The Formation of Minerals
Classes of Rock- Forming Minerals
Physical Properties of Minerals
What Are Rocks?
The Rock Cycle: Interactions Between the Plate Tectonic and Climate Systems
Concentrations of Valuable Mineral Resources

CH 4 IGNEOUS ROCKS: SOLIDS FROM MELTS
How Do Igneous Rocks Differ from One Another?
How Do Magmas Form?
Magmatic Differentiation
Forms of Igneous Intrusions
Igneous Processes and Plate Tectonics

CH 5 VOLCANOES
Volcanoes as Geosystems
Lavas and Other Volcanic Deposits
Eruptive Styles and Landforms
Interactions of Volcanoes with Other Geosystems
The Global Pattern of Volcanism
Volcanism and Human Affairs

CH 6 SEDIMENTATION: ROCKS FORMED BY SURFACE PROCESSES
Surface Processes of the Rock Cycle
Sedimentary Basins: The Sinks for Sediments
Sedimentary Environments
Sedimentary Structures
Burial and Diagenesis: From Sediment to Rock
Classification of Siliciclastic Sediments and Sedimentary Rocks
Classification of Chemical and Biological Sediments and Sedimentary Rocks

CH 7 METAMORPHISM: ALTERATION OF ROCKS BY TEMPERATURE AND PRESSURE
Causes of Metamorphism
Types of Metamorphism
Metamorphic Textures
Regional Metamorphism and Metamorphic Grade
Plate Tectonics and Metamorphism

CH 8 DEFORMATION: MODIFICATION OF ROCKS BY FOLDING AND FRACTURING
Plate Tectonic Forces
Mapping Geologic Structure
How Rocks Deform
Basic Deformation Structures
Styles of Continental Deformation
Unraveling Geologic History

CH 10 EARTHQUAKES
What Is an Earthquake?
How Do We Study Earthquakes?
Earthquakes and Patterns of Faulting
Earthquake Hazards and Risks
Can Earthquakes Be Predicted?

CH 11 EXPLORING EARTH’S INTERIOR
Exploring Earth’s Interior with Seismic Waves
Layering and Composition of Earth’s Interior
Earth’s Internal Temperature
Visualizing Earth’s Three-Dimensional Structure
Earth’s Magnetic Field and the Geodynamo

651-3072-AAL Fundamentals of Geology II: Surface of the Earth  E- 3 credits  6R  V. Picotti, W. Behr
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The surface of the Planet Earth, main processes and formation of Sedimentary rocks in various environments. Time in Geology, stratigraphy and fossils, relative and absolute ages. Surface processes, water in the surface and subsurface, ice and glaciers. Climate systems, Carbon cycle. Impact of human activities, anthropogenic climate change. Geobiology and early history of Planet Earth.
Objective

Understanding the processes and environments of Planet Earth. The peculiar way of reading the fossil record in Geology: understanding stratigraphy and time in the frame of the actual sedimentary environments. Mineral/life interactions and the impact of anthropic activities.
**Content**


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| CH 12 THE CLIMATE SYSTEM                              |
|-------------------------------------------------------|--|
| What Is Climate?                                      |
| Components of the Climate System                      |
| The Greenhouse Effect                                 |
| Climate Variation                                     |
| The Carbon Cycle                                      |

| CH 13 CIVILIZATION AS A GLOBAL GEOSYSTEM             |
|-------------------------------------------------------|--|
| Growth and Impact of Civilization                    |
| Fossil-Fuel Resources                                 |
| Alternative Energy Resources                          |
| Our Energy Future                                     |

| CH 14 ANTHROPOGENIC GLOBAL CHANGE                    |
|-------------------------------------------------------|--|
| Rise of Carbon Dioxide in the Atmosphere: The Keeling Curve |
| Types of Anthropogenic Global Change: Chemical, Physical, and Biological |
| Climate Change                                        |
| Ocean Acidification                                   |
| Loss of Biodiversity                                  |
| Managing the Carbon Crisis                            |

| CH 15 GLACIERS: THE WORK OF ICE                      |
|-------------------------------------------------------|--|
| Types of Glaciers                                     |
| How Glaciers Form                                     |
| How Glaciers Move                                     |
| Isostasy and Sea Level Change                         |
| Glacial Landscapes                                    |
| Glacial Cycles and Climate Change                     |

| CH 16 EARTH SURFACE PROCESSES AND LANDSCAPE DEVELOPMENT |
|--------------------------------------------------------|--|
| Controls on Weathering                                 |
| Chemical Weathering                                    |
| Physical Weathering                                    |
| Soils: The Residue of Weathering                       |
| Erosion and Formation of Stream Valleys                |
| Mass Wasting                                           |
| Classification of Mass Movements                       |
| Geomorphology and Landscape Development                |

| CH 17 THE HYDROLOGIC CYCLE AND GROUNDWATER           |
|-------------------------------------------------------|--|
| The Geologic Cycling of Water                         |
| Hydrology and Climate                                 |
| The Hydrology of Groundwater                          |
| Erosion by Groundwater                                |
| Water Quality                                         |
| Water Deep in the Crust                               |

| CH 18 STREAM TRANSPORT: FROM MOUNTAINS TO OCEANS      |
|-------------------------------------------------------|--|
| The Form of Streams                                   |
| Where Do Channels Begin? How Running Water Erodes Soil and Rock |
| How Currents Flow and Transport Sediment              |
| Deltas: The Mouths of Rivers                          |
| Streams as Geosystems                                 |

| CH 19 COASTLINES AND DESERTS                         |
|-------------------------------------------------------|--|
| Coastal Processes                                     |
| The Shaping of Shorelines                             |
| Hurricanes and Coastal Storm Surges                   |
| Desert Processes                                      |
| Windblown Sand and Dust                               |
| The Desert Environment                                |
| Tectonic, Climatic, and Human Controls on Deserts     |

| CH 20 EARLY HISTORY OF THE TERRESTRIAL PLANETS        |
|-------------------------------------------------------|--|
| Origin of the Solar System                            |
| Early Earth: Formation of a Layered Planet            |
| Diversity of the Planets                              |
| What's in a Face? The Age and Complexity of Planetary Surfaces |
| Mars Rocks!                                           |
| Exploring the Solar System and Beyond                 |

| CH 22 GEOBIOLOGY: LIFE INTERACTS WITH EARTH           |
|-------------------------------------------------------|--|
| The Biosphere as a System                             |
| Microorganisms: Nature's Tiny Chemists                |
| Geobiological Events in Earth's History              |
| Evolutionary Radiations and Mass Extinctions          |
| Astrobiology: The Search for Extraterrestrial Life    |
651-3401-AAL  Fundamentals of Geochemistry I: Chemistry of the Earth and the Solar System
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Fundamentals of Geochemistry I is designed as self-study course for new MSc students who have gaps in geochemical education. The topics of this course are related to the chemistry of the Earth and the Solar System.

Objective
Understanding of the fundamental concepts related to the chemistry of the Earth and the Solar System. Study material and specific content is provided as a Moodle course.

Content
1) Chemistry of the Earth
- structure of the Earth and chemical characteristics of its main units: crust, mantle, core
- the silicate Earth: oceanic and continental crust, and major rock-forming minerals of crust and mantle
- seismic discontinuities and mineral phase transitions

2) Chemistry of the Solar System
- classification of the elements: atmophile, lithophile, chalcophile, siderophile; volatile, refractory
- relation between composition of the solar photosphere and CI chondrites
- relation between CI and other chondrites and Earth

Prerequisites / notice
Enrollment ONLY for MSc students with an additional admission requirement.

651-3402-AAL  Fundamentals of Geochemistry II: Geochemical Systematics of the Earth's Interior
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Fundamentals of Geochemistry II is designed as self-study course for new MSc students who have gaps in geochemical education. Topics are related to generation of magmas and their chemical and isotopic signatures.

Objective
Understanding of the fundamental concepts related to the generation of magmas and their chemical and isotopic signatures. Study material and specific content is provided as a Moodle course.

Content
Generation of magmas and their chemical and isotopic signatures:
- partial melting and differentiation of magmas, element compatibility and the significance of trace elements
- divergent plate boundaries, decompression melting and mid ocean ridge basalts
- convergent plate boundaries, subduction and dehydration melting
- intraplate volcanism, ocean island basalts
- basics of isotope geochemistry, parent-daughter relations, e.g. Sm-Nd, W-Hf as example
- geochemical mantle reservoirs and signatures of recycled crust

Prerequisites / notice
Enrollment ONLY for MSc students with an additional admission requirement.

Earth Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
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Key for Hours

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<tr>
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<td>A</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Mathematics Education Master

Courses Offered

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<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>E. Stern, M. Rau</td>
</tr>
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</table>

Abstract
This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Objective
Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content

- Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:

Lecture notes
Folien werden zur Verfügung gestellt.

Literature

Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

871-0238-01L | Support and Diagnosis of Knowledge Acquisition Processes (EW3) | W    | 3 credits | 3S    | C. M. Thurn, S. Daguati |

Abstract
In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

Objective
The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

Competencies

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving
- Social Competencies: Communication, Cooperation and Teamwork, Leadership and Responsibility, Sensitivity to Diversity
- Personal Competencies: Creative Thinking, Critical Thinking

Mathematics Education Master - Key for Type

| W+        | Eligible for credits and recommended | O    | Compulsory |
| W         | Eligible for credits                | Z    | Courses outside the curriculum |
| E-        | Recommended, not eligible for credits | Dr   | Suitable for doctorate |

Key for Hours

- V = lecture
- G = lecture with exercise
- U = exercise
- S = seminar
- K = colloquium
- P = practical/laboratory course
- A = independent project
- D = diploma thesis
- R = revision course / private study

ECTS = European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings fostered in the learning process and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

### Abstract

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

### Objective

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

### Content

Themenatische Schwerpunkte:

Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:


### Lecture notes

Folien werden zur Verfügung gestellt.

### Literature


### Prerequisites / notice

This course is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

---

### Support and Diagnosis of Knowledge Acquisition Processes (EW3)

Enrolment only possible with matriculation in Teaching Diploma, who complete the sport-specific course unit EW3 and for students who intend to enrol in the "Teaching Diploma".

### Prerequisites:

Successful participation in 871-0240-00L "Human Learning (EW1)".

### Abstract

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

### Objective

The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

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**Science Education Master**

**Educational Science (for all Directions)**

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**Abstract**

This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma" or "Teaching Certificate". It is about learning in childhood and adolescence.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen

**Lecture notes**

Folien werden zur Verfügung gestellt.

**Literature**


**Prerequisites / notice**

This course is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

---

**Support and Diagnosis of Knowledge Acquisition Processes (EW3)**

Enrolment only possible with matriculation in Teaching Diploma, who complete the sport-specific course unit EW3 and for students who intend to enrol in the "Teaching Diploma".

**Prerequisites:**

Successful participation in 871-0240-00L "Human Learning (EW1)".

**Abstract**

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

**Objective**

The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
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**Biological Direction**

**Specialised Courses**

**Introductory Courses**

Selection of courses will be agreed with the course coordinator.

**Spec. Courses in Respective Subject with Educational Focus**

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<tr>
<th>Number</th>
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<td>551-0973-00L</td>
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<td>4</td>
<td>3G</td>
<td>H. Stocker, Y. Barral, K. Köhler</td>
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**Abstract**

Specialist aspects of biology with a focus on evolution are covered from the angle of imparting these to pupils, their historical development, and their significance for the subject, the individual and society.

**Objective**

After successful completion of the module, students should be able:
1. To retrieve in-depth knowledge of biology with a special focus on evolution and to impart this to others.
2. To analyse controversial topics and to give factual explanations for these.
3. To prepare teaching units suitably tailored to the recipients, with complex learning matter on a high professional level.

**Content**

Selected biological topics, with a special focus on evolution, are dealt with under consideration of the special needs of persons involved in teaching.

**Lecture notes**

Teaching materials are available online on Moodle.
The Specialized Biology Course with an Educational Focus can be acknowledged, in agreement with the advisor of the respective elective major, as one of the two obligatory research projects. In such a case, additional 3 CP must be obtained in another course.

In case of overbooking of the course, students enrolled in the Teaching Diploma in Biology will have priority.

### Subject Didactics

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<tr>
<td></td>
<td>Implementation of Subject Didactics I and II with the focus on conducting biological experiments in schools. This includes finding, testing and further developing suitable protocols for different subject areas of school biology. Working out how to didactically embed the experiments in lessons. Students can perform, off the cuff, 12 school experiments (which they have tested themselves), from the different subject areas, and conduct these correctly in technical terms. They can incorporate these experiments in their tuition in a didactically meaningful manner. Comments: By contrast to the Subject Specialisation 1 and 2 course units, these are &quot;basic tests&quot; and do not involve the implementation of current research topics. The students' compilations are available in a data archive.</td>
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</tbody>
</table>

- Students must complete the Einführungspraktikum (SA 551-0968-00L) - compulsory.
- Students can discuss and put into practice in their teaching work the conditions and objectives set out in the regulations governing the school-leaving examination (Matura), the framework curriculum and the conditions and objectives specified by their school.
- Students are able to characterize and to discuss the model of outcomes based education.
- They can reduce the complexity of subject-based specialist contents and present them in such a way that they are comprehensible and meaningful for learners. - They can select appropriate media for their work (e.g. school books) and use these. They can employ appropriate experiments. - The students can use different forms of examination for monitoring performance. - Students are in a position to implement and discuss the concepts of biology teaching and learning on the basis of specific topics covered in school biology.

- Lecture notes
- Prerequisites / notice
- Der Teil biologische Experimente findet im Rahmen von 7 Halbtagen statt.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0971-00L</td>
<td>Subject Didactics Biology I</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>P. Faller</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in Introductory Internship Biology</td>
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<tr>
<td></td>
<td>- course 551-0968-00L - is compulsory.</td>
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<tr>
<td></td>
<td>Wird laufend in der Vorlesung abgegeben.</td>
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<tr>
<td></td>
<td>Studierende müssen LE zusammen mit dem Einführungspraktikum - LE 551-0968-00L - belegen.</td>
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</tbody>
</table>

- Lecture notes
- Prerequisites / notice
- Teaching Science in Higher Education | W | 3 | 1V | G. Schiltz |
| Objective | This course imparts fundamental didactic concepts that are relevant to teaching science in a Higher Education context. Students are able to characterize and to discuss the model of outcomes based education. Students are able to transfer the basic concepts of this model (ILO, TLA, assessment, constructive alignment) to science education. |          |      |       |           |

(Please read the book in the 5th edition of 2022 before the first lecture started.)
### Chemical Direction

### Specialised Courses

### Introductory Courses

#### Spec. Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0962-00L</td>
<td>Fundamental Aspects of Chemistry with an Educational Focus I</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>C. Thilgen, R. Grass, A. Togni</td>
</tr>
</tbody>
</table>

**Information for UZH students:**
Enrolment to this course unit only possible at ETH. No enrolment to module CHE406 at UZH.
Examination Registration only at ETH.

- Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

**Abstract**
Selected topics in general chemistry:
1) The language of chemistry
2) Chirality and stereochemistry
3) Chemistry and sustainability.

**Objective**
In this course, participants acquire extended and more in-depth knowledge of selected chemistry topics. The selection is based to a large extent on the partial aspects of chemistry that are typically taught at high school. By gaining a broader understanding, teachers are put in a position where they can comprehend the topics that are to be taught in a wider and, to some extent, unconventional context and critically process these in respect of their teachability and learnability. At the same time, interrelationships between the classical sub-disciplines of chemistry are highlighted, along with the unique features of chemistry as one of the central natural sciences.

**Content**
The FV primarily conveys basic subject knowledge. Didactic aspects or even concrete suggestions for the design of grammar school lessons are possible, but not central.

**Learning format:** Lecture.

**Thematic focus of FV I:**
- The language of chemistry: Concepts, formulas, aesthetics, and philosophical aspects
- Stereochemistry: The Coupe du Roi and its chemical meaning, Cyclostereoisomerism, Origin of biomolecular homochirality
- Chemistry and sustainability. The link between chemical products and energy consumption, life cycle assessments and chemical energy storage

**Lecture notes**
Slides and selected literature will be provided.

**Literature**
Selected articles from the primary literature are presented, commented on and recommended reading.

**Prerequisites / notice**
FV I (fall semester) and FV II (spring semester) do not build upon each other. The order in which they are taken is therefore indifferent.

### Subject Didactics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0950-00L</td>
<td>Subject Didactics Chemistry I</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>P. Aschwanden</td>
</tr>
</tbody>
</table>

**Simultaneous enrolment in Introductory Internship Chemistry - course 529-0966-00L - is compulsory.**

**Abstract**
Implementing findings from research into teaching and learning for chemistry lessons and coverage of subject-specific teaching and learning specialties.

**Objective**
The students have basic subject didactic knowledge for teaching chemistry at a secondary school. They are able to design lessons that are effective for learning, actively involve students in lessons, explain challenging concepts simply, use experiments for theory and reflect on teaching.
Content

Schwerpunkte im ersten Studiensemester bilden die folgenden Themen:
- Auswahl gymnasiumsrelevanter Lerninhalte
- Didaktische Vereinfachung
- Modelle und chemischen Formeln zur Beschreibung von Aufbau und Umwandlung der Substanzen
- Wechselfläche zwischen Beobachtung in der realen Welt und Deutung auf Modell-Ebene
- Skizzen entwerfen und zur Erklärung von Reaktionen nutzen
- Chemie im 8. Schuljahr: Das Teilchenmodell erklärt viele Phänomene im Anfangsunterricht
- Atommodelle und chemische Bindung
- Radioaktivität und Kernspaltung
- Struktur und Eigenschaft
- Auswahl, Konzeption, Durchführung, Einbettung und Auswertung von Demonstrations-Experimenten

Lecture notes

Die Unterlagen sind auf der Plattform http://fdchemie.pbworks.com zugänglich

Literature

- E. Rossa: Chemie-Didaktik, Cornelsen Verlag, 2015
- H.-J. Bader et al: Konkrete Fachdidaktik Chemie, Oldenbourg Verlag, 2002

Prerequisites / notice

Der Chemieunterricht am Gymnasium soll einerseits grundlegende chemische Kenntnisse für den Alltag vermitteln und andererseits auf ein naturwissenschaftlich orientiertes Hochschulstudium vorbereiten. Diese beiden Ziele sind im Unterricht gleichermassen zu berücksichtigen.

Da viele Lerninhalte sequentiell und einander benützend strukturiert sind, ist dem logischen Aufbau des Unterrichts besonderes Augenmerk zu schenken. Dies bedingt eine feine Abstimmung von fachlichen Inhalten und didaktischen Methoden auf die kognitive Leistungsfähigkeit der Lernenden.

Anhand der Diskussion bewährter Beispiele und dem Entwurf eigener Unterrichtsbausteine soll die zukünftige Lehrperson befähigt werden, einen den spezifischen Rahmenbedingungen angepassten Unterricht zu entwickeln, der diesem hohen Qualitätsanspruch genügt.

402-0091-00L Teaching Science in Higher Education

Abstract

This course imparts fundamental didactic concepts that are relevant to teaching science in a Higher Education context.

Objective

Students are able to characterize and to discuss the model of outcomes based education.

Lecture notes

keines

Literature


(Please buy the book in the 5th edition before the first meeting.)

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Problem-solving

Social Competencies

Communication

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Self-awareness and Self-reflection

Self-direction and Self-management

402-0737-00L Energy and Sustainability in the 21st Century (Part I)

Abstract

Part I of this course covers the energy-related topics in this two-semester course. The importance of energy to life and our modern culture is explored and placed in the perspective of the ongoing energy transition in the context of necessary and urgent decarbonization efforts. How much energy do we need and how can it be provided in a way that enables a sustainable existence?

Objective

Why is energy important for life, economy and our society?

How did energy use change over time? Which effects did these changes have on the environment?

What are the physical basics of energy technologies?

When, why and how did technology and science of energy come together?

What are the limits and benefits of all the various energy technologies?

How can different energy technologies be compared?

Can we understand the changes in the current energy systems?

How will the energy systems of the future look like?

How fast can we and should we enforce the current energy transition?

Which could be the overall guidelines for a working and sustainable energy system of the future?
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literatur
The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
Clean Disruption of Energy and Transportation, T. Seba 2014
Energy and Civilization: A History, V. Smil. 2018

Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.

Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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</table>

Subject Didactics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0910-00L</td>
<td>Physics Didactics I: Special Didactics of Physics Teaching</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Mohr</td>
</tr>
</tbody>
</table>

Limited number of participants.

Further information is available from the lecturer via email: mamohr@ethz.ch

Simultaneous enrolment in Introductory Internship Physics - course 402-0920-00L - is compulsory for Teaching Diploma Physic

Objective

Content
Themen der Veranstaltung:
Fachspezifisches: Sachstrukturen der gängigen Unterrichtsthemen, Alltagsbezüge, Fehlerverhütung, Demonstrationen- und Schülerexperimente, Arbeitsmittel zu physikalischen Themen des Grundlagen- und Schwerpunktuunterrichts
Einsatz verschiedener Unterrichtsmaterialien: Experimente, Computer, Taschenrechner, Video, Simulation
Unterrichtsfenster: Lernaufgabe, Werkstatt, Puzzle, Projekt, Gruppenarbeit, Praktikum
Lernformen
Interaktive Lehr-Lernveranstaltungen mit Vorträgen und Demonstrationen des Dozenten, studentischer Einzel- und Kleingruppenarbeit, kurzen Präsentationen der Studierenden, Übertragung der Inhalte durch Bearbeitung von Aufträgen ausserhalb der Kontaktstunden

Lecture notes
Folien und weitere Unterlagen werden zur Verfügung gestellt

Literature

Prerequisites / notice
Die Veranstaltung ist zusammen mit dem Einführungspraktikum zu belegen

402-0901-00L | Teaching Science in Higher Education | W | 3 credits | 1V | G. Schiltz

This course imparts fundamental didactic concepts that are relevant to teaching science in a Higher Education context.

Objective
Students are able to characterize and to discuss the model of outcomes based education.

Lecture notes
keines

(Please the book in the 5th edition of 2022 for the first meeting erwerben!)

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
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<tr>
<td>assessed</td>
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<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Problem-solving</td>
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<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
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<td>assessed</td>
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<td>assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<td>Self-awareness and Self-reflection</td>
<td>Self-direction and Self-management</td>
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<td>assessed</td>
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<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Sensitivity to Diversity</td>
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<td>assessed</td>
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</table>

Method-specific Competencies

- Decision-making assessed
- Problem-solving assessed

Social Competencies

- Communication assessed
- Customer Orientation assessed
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed

Personal Competencies

- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Natural Sciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-3001-00L</td>
<td>Dynamic Earth I</td>
<td>W</td>
<td>6</td>
<td>4V+2U</td>
<td>O. Bachmann, A. Galli, A. Fichtner, M. Schönbächler, S. Willett</td>
</tr>
</tbody>
</table>

Abstract

Provides a basic introduction into Earth Sciences, emphasizing different rock-types and the geological rock-cycle, as well as introduction into geophysics, plate tectonics and planetology.

Objective

Understanding basic geological and geophysical processes

Content

Overview of the Earth as a system, with emphasis on plate tectonic theory and the geological rock-cycle. Provides a basic introduction to crystals and minerals and different rock-types. Lectures include processes in the Earth's interior, physics of the earth, planetology, introduction to magmatic, metamorphic and sedimentary rocks. Exercises are conducted in small groups to provide more in depth understanding of concepts and content of the lectures.

Literature

Grotzinger, J., Jordan, T.H., 2020, Understanding Earth, Macmillan Learning, 8th Ed.

Prerequisites / notice

Exercises and short excursions in small groups (10-15 students) will be lead by student assistants. Specific topics in earth sciences will be discussed using examples and case studies. Hand samples of the major rock types will be described and interpreted. Short excursions in the region of Zurich will permit direct experience with earth science processes (e.g. earth surface processes) and recognition of earth science problems and solutions relevant for modern society (e.g. building materials, water resources). Working in small groups will allow for discussion and examination of actual earth science themes.

Science Education Master - Key for Type

| W+ | Eligible for credits and recommended | O   | Compulsory |
| W  | Eligible for credits               | Z   | Courses outside the curriculum |
| E- | Recommended, not eligible for credits | Dr  | Suitable for doctorate |

Key for Hours

| V  | lecture                              | P   | practical/laboratory course |
| G  | lecture with exercise                | A   | independent project         |
| U  | exercise                             | D   | diploma thesis              |
| S  | seminar                             | R   | revision course / private study |
| K  | colloquium                           |     |                              |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Lecturers

Didactic Basics for Student Teaching Assistants

Abstract

The course "Didactic Basics for Student Teaching Assistants" enhance Student Teaching Assistants (Student TAs) to develop knowledge, capability and confidence to effectively plan and teach courses and exercises. Participants get trained to think critically about students' learning and create learning situations in which students are actively engaged.

Objective

In this course Student Teaching Assistants will:

- reflect on their approach to teaching as well as their attitude towards teaching.
- understand the basics of teaching and learning in the context of their subject.
- consciously design the introduction of their course as well as the introduction of single teaching units.
- apply classroom assessment techniques as formative assessments to measure the current status of their students.
- develop a didactic concept according to the learning objectives.
- conduct interactive sequences as learning activities.
- give and get feedback from peers and self-reflect on their teaching practice.
- feel confident to use methods for active learning scenarios in their classes.

Content

The course "Didactic Basics for Student Teaching Assistants" enhance Student Teaching Assistants (Student TAs) to develop knowledge, capability and confidence to effectively plan and teach courses and exercises. Participants get trained to think critically about students' learning and create learning situations in which students are actively engaged.

Method-specific Competencies

- fostered

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>1S</td>
<td>1</td>
<td></td>
<td>B. Volk</td>
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</tbody>
</table>

Prerequisites / notice

Consolidation Workshops takes place online or in presence (you have the choice). Dates will be released at the beginning of the new semester.

Competencies

Method-specific Competencies

- Media and Digital Technologies

Social Competencies

- Communication
- Cooperation and Teamwork

Personal Competencies

- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Coaching Students

Abstract

The course "Coaching Students" enhance Student Teaching Assistants (Student TAs) in their role as student coaches to develop basic knowledge about coaching methodology and the mindset of a coach.

Objective

In this course Student Teaching Assistants will ...

- understand the basics of coaching and the role as student coaches.
- develop the mindset of a coach and reflect on their attitude towards guiding student learning processes.
- acquire coaching skills and build knowledge and know-how about coaching methods.
- design the coaching session and feel confident to use coaching methods.
- give and get feedback from peers and self-reflect on their coaching practice.

Content

The course starts with a Kick-off meeting in the first lesson to provide an overview of the role as student coach and the course in general. Participation in the Kick-off (1st live session) is essential, since during this session the groups are formed in which the students will work throughout the semester.

The further 4 live sessions will provide a range of relevant topics for developing coaching competencies:

- Overview about coaching: Based on this, participants reflect on their role as student coaches in order to develop the mindset of a coach,
- Introduction into coaching methodology,
- Coaching skills training: active listening, asking questions and giving/getting feedback.
- Design the coaching session and feel confident to use coaching methods.
- Give and get feedback from peers and self-reflect on their coaching practice.

During the last live session, course participants will be able to apply their knowledge and the coaching skills learned during the course in a role play. The last meeting is also mandatory for the participants.

Further, the course also consists of an online part. The online part offers a short theoretical overview of each live session and the possibility to conduct a learning journal.

Prerequisites / notice

This course takes place on the campus of ETH Zurich. The room for our meetings will be HG D18.1.

We will meet 6 times on Wednesdays. Overview of course topics sorted according to the live sessions on Wednesdays from 4:15pm-6pm (16:15-18h):

- Kick-off: Information about the course, role as a student coach
- Teambuilding & Psychological Safety
- Active listening
- GROW & Asking questions
- Feedback
- Role play: practice the skills you have learned during the semester

Dates will be released soon.
We will meet for the mandatory kick-off meeting online in October. You will get detailed information together with the invitation email.

This is an online course that participants can work through at their own pace. The course is in English and takes about 6 hours to complete.

**Military Studies**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0037-01L</td>
<td>Military Psychology and Pedagogy I (Without Exercises)</td>
<td>Z</td>
<td>3</td>
<td>2V</td>
<td>H. Annen</td>
</tr>
</tbody>
</table>

**Abstract**
Examine the fundamentals of the two sciences and establish links with military life. Discuss various schools of thought in psychology and focus on content and process theories of motivation. Explore characteristics of pedagogical thinking and discuss the values of military education with reference to the young adult serving in the armed forces.

**Objective**
- Becoming acquainted with basic psychological views of human behaviour and experience
- Knowing content- and process theories of motivation and being able to transfer them to the military context
- Knowing the possibilities and limitations of military education and deriving consequences

**Content**
Overall, the objective is to become acquainted with the basics of both scientific areas and to make references to military practice. Military psychology is a branch of applied psychology; consequently selected aspects of psychological principles will be covered. Military pedagogy hasn't yet established itself firmly as an independent scientific discipline, it nevertheless can draw on a deep-seated tradition in Switzerland. Thus, the great importance that has been attached to the discussion of education in Swiss society and academia will be taken into account.

Subjects:
- History of military psychology
- Introduction to psychological thinking
- Motivational theories
- Defence-, service-, operational- and combat motivation
- Swiss military pedagogy
- Education as defining feature of pedagogic thinking and acting

**Literature**
- Annen, H., Steiger, R. & Zwygart, U.: Gemeinsam zum Ziel, Huber, Frauenfeld 2004 (provided as pdf)
- Stadelmann, J.: Führung unter Belastung, Huber, Frauenfeld 1998 (provided as pdf)

The lecture is supported by a virtual learning environment containing relevant documents (presentations and texts) and information to further literature.
853-0063-02L Military History I (Without Exercises) Z 3 credits 2V M. Olsansky, T. Cubito, A. Wettstein

Abstract
The purpose of the lecture is to outline the development of the armed forces (assets regarding manpower, technology and armament), the concepts of warfare and the actual warfare in the 19th and 20th century.

Objective
- Distinguish between military history as a subject and historiography as a way of describing events;
- Analyse the modern developments regarding armed forces and warfare in the context of socio-economic changes;
- Based on the approach regarding revolution in military affairs, describe the evolution of the armed forces and of warfare;
- Exemplify the issues regarding the evolution of the combat (First and Second World War, Vietnam War and Algerian War).

Content
The lecture first examines the bases of the science of (military) history. It focuses on how military history developed from war history, on specific similarities and differences between military history and general historiography, the different ways of dealing with history in Switzerland, Germany, France and in the Anglo-Saxon cultural area (different approaches) as well as on institutions which deal with military history such as universities, military academies, national and international commissions and associations etc.

The lecture is structured along the lines of the concept of “Military Revolution” and starts with the formation of modern, European armed forces after the Oranian Army reform in the 17th century.
Based on the “Military Revolution” approach, the lecture examines the structural changes regarding the armed forces and the development of warfare from the 18th to the 20th century. Special emphasis will be put on how the battlefield was revolutionized due to the Napoleonic wars, the industrialization in the 19th century, the First World War, the mechanization and totalization during the Second World War and the period of the Cold War.

Literature

853-0064-00L Military Sociology I Z 3 credits 2V T. Szvircsev Tresch, S. De Rosa, T. Ferst

Abstract
Beside of the most important terms of sociology, demographic changes and the related value and structure change will be analysed. The second part focuses on organizational sociology. Thirdly, the course examines to which extent armed forces can be considered as organizations like any other and to which extent they constitute a special case from an organizational and normative point of view.

Objective
- Recognize and explain current changes (social change) in modern society (individualisation, pluralisation); describe demographic changes in Switzerland; explain the structures of societies; define issues and fields of research in modern military sociology and explain the foundations of organisational sociology; explain the military in terms of organisational sociology and identify specific traits of the military as an organisation.

Content
Societal change, organizations as societal phenomena; aims, structures, environments of organizations; specifics of the military as an organization; impacts of technological and societal changes on the armed forces in modern societies.

Literature
A reader with a set of texts will be handed out.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving fostered
Project Management fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered

853-0101-02L Defense Economics I Z 3 credits 2V M. M. Keupp, M. Bader, F. Muhly, C. Schulze

Abstract
In terms of structure and content, the event follows the lecturer's book “Militärokonomie” (Military Economics), which is available in two language versions:
- German language: ISBN 978-3-658-06146-3

Objective
* Recognize and analyze planned economic systems;
* Analyze the modern developments regarding armed forces and warfare in the context of socio-economic changes;
* Exemplify the issues regarding the evolution of the combat (First and Second World War, Vietnam War and Algerian War);
* Recognize and explain current changes (social change) in modern society (individualisation, pluralisation); describe demographic changes in Switzerland, Germany, France and in the Anglo-Saxon cultural area (different approaches) as well as on institutions which deal with military history such as universities, military academies, national and international commissions and associations etc.

* Understand the link between institutions, human action and economic results.
Content

The semester program of the course is divided into 14 modules of 90 minutes each, which combine lecture (teaching of analytical techniques) and exercise (application by means of concrete case studies).

The contents correspond to sections 1 to 2.2.5 of the above book. The following will be discussed:

1. fundamental military economic problems including historical introduction to the topic
2. the institutional foundations of a military organisation
3. the modern military as a planned economy system
4. actors and stakeholders in the system

Lecture notes

Lecture slides are given to the participants before the first lecture. In addition, the above mentioned book will be handed over to the participants. Participants of the lecture who are not professional officer candidates are requested to obtain the book from the library or bookstore.

Literature

ISBN 978-3-658-06146-3

ISBN 978-3-658-25287-8

Prerequisites / notice

none.

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

Personal Competencies

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Leadership I

Z 3 credits

Abstract

The lectures "Leadership I" (WS) and "Leadership II" (SS) have been designed as a two-semester lecture series, but may also be followed independently of one another or in reverse order. "Leadership I" covers the following fields: leadership basics, leadership theories and leadership styles, the concept of leadership responsibility and the role of communication in practical leadership.

Objective

The aim of this lecture is to give students an introductory overview of relevant topics regarding leadership research and practice, thus enabling them to gain a deeper understanding of the leadership phenomenon. Students should understand different concepts of leadership in the complex interaction between individuals, groups, organizations, contexts, and situations. They should grasp the concept of leadership responsibility (leadership ethics) and be able to derive consequences for leadership in practical situations. They should recognize the fundamental importance of communication in leadership situations and receive input that enables them to communicate adequately in specific situations.

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
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- Sensitivity to Diversity: assessed
- Negotiation: fostered

Personal Competencies

- Adaptability and Flexibility: assessed
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- Self-direction and Self-management: fostered

Specialized Continuing Education

Special internal ETH courses offered by LET and the Teaching Specialists.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>999-9999-99L</td>
<td>EduApp Course</td>
<td>E-</td>
<td>0</td>
<td>1V+1U</td>
<td>B. Volk</td>
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</table>

This course unit is not a genuine ETH course unit. It is used by LET and the Teaching Specialists for EduApp demonstration purposes.
### Humanities, Social and Political Sciences (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
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</table>

ECTS | European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
**Geography Teaching Diploma**

More informations at: https://www.ethz.ch/de/studium/didaktische-ausbildung/studienangebot-zulassung/lehrdiplom-fuer-maturitaetsschulen.html

► Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
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<td>see Educational Science Teaching Diploma</td>
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<tr>
<td>871-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td>Abstract</td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td>Objective</td>
<td>- Get to know cognitively activating instructions in MINT subjects - Get information about recent literature on learning and instruction</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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<td>871-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
<tr>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td>Abstract</td>
<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<tr>
<td>Objective</td>
<td>- Understanding of research methods used in the empirical human sciences - Getting to know intelligence tests - Understanding findings relevant for education</td>
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<tr>
<td>871-0229-00L</td>
<td>Using Outdoor Education</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>R. Schumacher, P. Faller</td>
</tr>
<tr>
<td>Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.</td>
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<tr>
<td>Abstract</td>
<td>In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.</td>
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<tr>
<td>Content</td>
<td>Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf: - Dendrochronology: What annual rings tell - Photosynthesis/Climate change: The tracks in the forest - Forest Soil: The soil in the focus of the climate</td>
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</table>

► Subject Didactics in Geography

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4239-00L</td>
<td>Subject Didactics Geography I (University of Zurich)</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: 090GG1</td>
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<tr>
<td>Abstract</td>
<td>Fundamentals (theory and practice) of specialist subject teaching for high-school geography lessons.</td>
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<tr>
<td>Objective</td>
<td>Die Studierenden lernen Theorie und Praxis im Unterricht zu verbinden, verschiedene Unterrichtsmethoden und -mittel einzusetzen sowie ihren Unterricht zu planen, durchzuführen und zu reflektieren.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>A maximum of 12KP additional requirements in Geography may be open before registering for the didactics Geography.</td>
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<tr>
<td>Please provide the form <a href="https://ethz.ch/content/dam/ethz/main/education/didaktische-ausbildung/Files/Diverses/Form_Auflagen_bis%2012%20KP_291015.pdf">https://ethz.ch/content/dam/ethz/main/education/didaktische-ausbildung/Files/Diverses/Form_Auflagen_bis%2012%20KP_291015.pdf</a> as a confirmation. Besides the module registration at University of Zurich, the responsible lecturer of the course must be informed by mail by 1 September.</td>
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<td>651-4124-00L</td>
<td>Examination Subject Didactics</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>S. Hesske, J. Rafflenbeul</td>
</tr>
<tr>
<td>Abstract</td>
<td>Die Prüfung Fachdidaktik bildet den Abschluss der didaktischen Ausbildung und wird nach erfolgreichem Abschluss aller Ausbildungsbereiche der didaktischen Ausbildung abgelegt.</td>
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</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1176 of 2667
Geprüft werden:
Fähigkeit, Geografie-Unterricht mit Bezug zur eigenen Praxis kritisch und unter verschiedenen Blickwinkeln (inhaltslich, methodisch-didaktisch) zu betrachten. Lernarrangements mit Bezug zum heutigen Bildungs- und Schulfachverständnis zu gestalten und kritisch zu hinterfragen sowie deren möglichen/erzielten Wirkungen zu diskutieren und zu begründen; Unterrichtssituationen zu reflektieren und zu evaluieren.

Unterlagen aus der fachdidaktischen Ausbildung
Lecture notes Unterlagen aus der Fachdidaktik
Literature

Prerequisites / notice
The Examination Didactics is completed at the end of studies and must be fulfilled together with both examination lessons I and II (651-2520-01 und 651-2520-02). The responsible lecturers must be informed in advance so that the examination date (and place) can be organized.

All of the following courses must be successfully completed: Geography Didactics I, II, III and the specialised courses in respective subjects I, II and III as well as the Introductory Internship and Internship.

The examination didactics is an 15-minutes oral exam that takes place at the same day together with the examination lessons I and II.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<tr>
<td>Problem-solving</td>
<td>Integrity and Work Ethics</td>
<td>Self-presentation and Social Influence</td>
<td>Self-direction and Self-management</td>
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<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>sensitivity to Diversity</td>
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Social Competencies

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<td>Self-awareness and Self-reflection</td>
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651-4120-00L Subject Didactics Geography IV: Mentored Project

Prerequisites: successful participation in Geography Didactics of Geography Teaching I, II, III

Abstract
Mentorierte Arbeit mit Bezug zur fachdidaktischen Ausbildung.

Objective
Selbständige, theoriegestützte Auseinandersetzung mit konkreter, praxisbezogener Fragestellung zum Geographieunterricht.

Content
Selbständige, mentorierte Arbeit zu einem Thema aus der Fachdidaktik mit direktem Bezug zur Lehrpraxis im Fach Geografie (z.B. zu eigenen Übungslektionen und Praktikum oder zur Unterrichtsforschung). Das Thema wird zu Beginn mit der Mentorin/ dem Mentor festgelegt.

Literature

Prerequisites / notice
May be completed together with didactics III at the earliest.

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
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<tbody>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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Social Competencies

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Personal Competencies

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651-4118-00L Subject Didactics Geography III (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 090GG3

Limited number of participants. In addition to the course enrollment a registration by email is required no later than September 1 for autumn semester, February 1 for spring
### Professional Training in Geography

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-2519-01L</td>
<td>Lesson Shadowing (University of Zürich)</td>
<td>O</td>
<td>1 credit</td>
<td>2P</td>
<td>University lecturers</td>
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<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
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<td>UZH Module Code: 090BPEP</td>
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<td>Mind the enrolment deadlines at UZH:</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>The Lesson Shadowing is part of the practical education of the teacher training for Upper Secondary Schools and must be completed at the beginning of studies.</td>
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<td>Prerequisites / notice</td>
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<td></td>
<td>The Lesson Shadowing is part of the practical training in the study program &quot;Teaching Diploma for Matura Schools&quot;. It must be completed at the beginning of the course - if possible in the 1st semester.</td>
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<td>The Lesson Shadowing can only be completed together with the practice lessons for didactics.</td>
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<tr>
<td>651-2519-02L</td>
<td>Lessons Training (University of Zürich)</td>
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<td>4P</td>
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<td>Abstract</td>
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<td>The practice lessons help students to gain first experiences in teaching and is completed together with the didactics courses.</td>
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<td></td>
<td>The practice lessons for didactics must be completed within the didactic courses.</td>
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<td></td>
<td>Students register for the module at UZH ideally together with didactics II. ECTS will be assigned after having handed in all relevant documents to the lecturers, at the earliest upon completion of didactics II.</td>
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<td>The Practice Lessons can only be completed together with an accredited internship teacher of ETH Zurich (<a href="https://cms-author.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/cug/Praktikumslehrpersonen_LD_Geographie.pdf">https://cms-author.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/cug/Praktikumslehrpersonen_LD_Geographie.pdf</a>).</td>
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<td>8 credits</td>
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<td>Prerequisites: Successful completion of Educational Science and Subject Didactics in Geography (FD I, II, III) as well as Spec. Courses in Resp. Subj. w/ Educ. Focus &amp; Further Subj. Didactics (FV I, II, III) plus completion of the introductory internship.</td>
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<td>The Introductory Internship can only be completed together with an accredited internship teacher of ETH Zurich (<a href="https://cms-author.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/cug/Praktikumslehrpersonen_LD_Geographie.pdf">https://cms-author.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/cug/Praktikumslehrpersonen_LD_Geographie.pdf</a>).</td>
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<tr>
<td>651-2520-01L</td>
<td>Examination Lesson I Geography ■</td>
<td>O</td>
<td>1 credit</td>
<td>2P</td>
<td>S. Hesske, J. Rafflenbeul</td>
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<td>To be completed together with Examination Lesson II 651-2520-02.</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.</td>
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<td>Objective</td>
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<td>On the basis of a specified topic, the candidate shows that they are in a position</td>
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<td>- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle</td>
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<td>- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.</td>
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</table>
Die Studierenden erfahren das Lektionsthema in der Regel 14 Tage vor dem Prüfungstermin. Von der zuständigen Lehrperson erhalten sie Informationen über den Wissensstand der zu unterrichtenden Klasse und können die Klasse einmal vor dem Prüfungstermin besuchen. Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie spätestens 2 Tage vor dem Prüfungstermin (bis 18 Uhr) den beiden Prüfungsexperten ein.

Die gehaltene Lektion wird kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/ der Kandidatin über die gehaltene Lektion im Rahmen eines Kolloquiums (max. 15 min).

The examination lessons I and II are completed at the end of the training together with the subject didactics examination. The responsible lecturers must be informed in advance so that the examination date (and place) can be organized.

The following parts of the course must be passed: Subject Didactics I, Subject Didactics II, Subject Didactics III, Subject Didactics IV. In addition FWV I, FWV II and FWV III, introductory internship and internship (incl. internship journal).

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

#### Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

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**651-2520-02L Examination Lesson II Geography **

*O 1 credit 2P  S. Hesske, J. Rafflenbeul*

*To be completed together with Examination Lesson I 651-2520-01.*

**Abstract**

In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

**Objective**

On the basis of a specified topic, the candidate shows that they are in a position
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

**Content**

Die Studierenden erfahren das Lektionsthema in der Regel 14 Tage vor dem Prüfungstermin. Von der zuständigen Lehrperson erhalten sie Informationen über den Wissensstand der zu unterrichtenden Klasse und können die Klasse einmal vor dem Prüfungstermin besuchen. Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie spätestens 2 Tage vor dem Prüfungstermin (bis 18 Uhr) den beiden Prüfungsexperten ein.

Die gehaltene Lektion wird kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/ der Kandidatin über die gehaltene Lektion im Rahmen eines Kolloquiums (15 min).

**Lecture notes**

Dokument: Schriftliche Vorbereitung für Prüfungslektionen.

**Prerequisites / notice**

The examination lessons I and II are completed at the end of the training together with the subject didactics examination. The responsible lecturers must be informed in advance so that the examination date (and place) can be organized.

The following parts of the course must be passed: Subject Didactics I, Subject Didactics II, Subject Didactics III, Subject Didactics IV. In addition FWV I, FWV II and FWV III, introductory internship and internship (incl. internship journal).
In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, students transfer the content of their subject-specific, educational and didactic training into teaching practice. While teaching, they gain and reflect on experience in the design of subject-specific lessons, in classroom management and in performance assessment at all levels of the Matura school.

Prerequisites / notice

The internship can only be completed after the teaching internship I at the end of the program in the same semester. Prerequisite is the successful completion of all courses of the teaching diploma program.

The internship can only be completed together with an accredited internship teacher of ETH Zurich (https://cms-author.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/cug/Praktikumslehrpersonen_LD_Geographie.pdf).

The internship is the successful completion of all courses of the teaching diploma program.

Prerequisites

The internship is the successful completion of all courses of the teaching diploma program.

Successful completion of Geography Didactics I (651-4239-00L).

Prerequisites / notice

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The internship is the successful completion of all courses of the teaching diploma program.
The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH myStudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

Credits and Exam
After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. Students who obtain a grade of < 4.0 for the test will have a second chance (see table below). Students who did not participate in the test on 18 December 2023 will not have access to the repeat test unless they submit compelling and documented (e.g. medical, other exam in parallel at ETH) reasons for why they were unable to participate in the first test. It covers all contents of the lectures and the reading assignments. Visiting students (e.g., from the University of Zurich or other universities) are subject to the same conditions. Registration for the course in the myStudies system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.

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Following an introductory lecture, students will split into four smaller seminar groups, focused on different thematic areas from urban, political and economic geography. Seminars will be based on a close reading of selected material and designed for interactive participation and discussion.

Each seminar consists of theory-oriented sessions, where students will gather first insights into selected theoretical perspectives of human geography; Using these perspectives, students develop their knowledge of each seminar group’s thematic area of focus and practice applying theory to empirical fields of research.

Prerequisites / notice

After the introductory lecture in week 1, students must enroll in one of four seminar groups via OLAT. Attendance of the introductory lecture is a prerequisite for participation in the first group session.

Module of Choice

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-2603-00L</td>
<td>Geography. Matters. (University of Zurich)</td>
<td>W</td>
<td>4 credits</td>
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</table>

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

The course aims are twofold. First, students will discuss urgent societal challenges (e.g. biodiversity loss, climate change, migration, urbanization, water scarcity) and outline how Geography as a whole can contribute tackling these challenges. Second, students are encouraged to reflect their individual interdisciplinary curricula.

Objective

The learning goals of this module comprise the following aspects:
- Understanding and being able to explain fundamental concepts of remote sensing
- Knowing basic image understanding techniques and being able to apply these to optical imagery.
- Being able to choose and apply appropriate data analysis methods to solve a given remote sensing task
- Being able to interpret data, critically discuss the results and draw reasonable conclusions

Module of Choice

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<tr>
<td>103-0214-00L</td>
<td>Cartography Fundamentals</td>
<td>W</td>
<td>5 credits</td>
<td>4G</td>
<td>L. Hurni</td>
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Abstract

Basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.

Objective

Acquire basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well designed legends for basic maps.

Content

Definitions “map” and “cartography”, map types, current tasks and situation of cartography, map history, spatial reference systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, prepress technology, printing technology, topographic maps, map critics.

Lecture notes

Will be distributed module by module.

Module of Choice

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Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

The course "Grundlagen der Fernerkundung" (Principles of Remote Sensing) introduces the underlying principles of remote sensing and a range of fundamental concepts for understanding, handling and manipulating remote sensing data and images. It provides first details on optical image geometries as well as image classification and time series analysis.

Objective

The learning goals of this module comprise the following aspects:
- Understanding and being able to explain fundamental concepts of remote sensing
- Knowing basic image understanding techniques and being able to apply these to optical imagery.
- Being able to choose and apply appropriate data analysis methods to solve a given remote sensing task
- Being able to interpret data, critically discuss the results and draw reasonable conclusions

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Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufes. Dabei werden einzelne Wasserspeicher (Schnee-, Boden und Grundwasser) und Flüsse zwischen den Speichern (Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.

Module of Choice

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Abstract

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Objective

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Content

Definitions “map” and “cartography”, map types, current tasks and situation of cartography, map history, spatial reference systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, prepress technology, printing technology, topographic maps, map critics.

Lecture notes

Will be distributed module by module.
Literature

Prerequisites / notice
Further information at http://www.karto.ethz.ch/studium/lehrangebot.html

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<th>Competencies</th>
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Geography Teaching Diploma - Key for Type

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<tr>
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<td>Eligible for credits and recommended</td>
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<td>E-</td>
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<td>Z</td>
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Key for Hours

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<td>K</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Students will exercise important aspects when doing research, such as doing a literature search, writing and referencing, and presenting.

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems.

Analytical Competencies

Concepts and Theories

Introduction to mathematical and statistical tools for geospatial data analysis.

M. Varga

Lecturers

M. Raubal

Hours

4 credits

4G

T. Medic

The course requires familiarity with linear algebra and analysis at the level of a BSc program in engineering or natural sciences.

Subject-specific Competencies

Creative Thinking

The course requires familiarity with linear algebra and analysis at the level of a BSc program in engineering or natural sciences.

Prerequisites / notice

Competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

assessed

Problem-solving

fostered

Personal Competencies

Critical Thinking

fostered

The course supports the students in acquiring an in-depth understanding of sensors, sensor systems and sensor networks for the acquisition of geospatial data. Emphasis is put on the prediction and assurance of data quality based on an understanding of key sensing principles, external influences, and data acquisition processes.

Prerequisites / notice

The course requires familiarity with linear algebra and analysis at the level of a BSc program in engineering or natural sciences.

Competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

fostered

Problem-solving

assessed

Personal Competencies

Critical Thinking

fostered

The course introduces basic methods of geostatistics and geospatial data analysis. Topics include spatial correlation, auto-correlation and the variogram; surface interpolation (kernel-based, kriging, parametric surface models); spatially adaptive filtering (bilinear, guided filter); spatial stochastic processes and random fields; time series models and spatio-temporal analysis.

Prerequisites / notice

Bachelor level mathematics: analysis, linear algebra, statistics and probability theory, parameter estimation. Basic knowledge of multivariate statistics and machine learning is recommended.

Competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

fostered

Problem-solving

assessed

Personal Competencies

Creative Thinking

fostered

Critical Thinking

fostered

The goal of this seminar-style course is to convey methods how to do research and communicate research results in the geospatial domain. The course further provides an overview of the types of research in the geospatial domain and the research life cycle.

Students will exercise important aspects when doing research, such as doing a literature search, writing and referencing, and presenting.

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

Transport Planning Methods

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems.

Prerequisites / notice

Bachelor level mathematics: analysis, linear algebra, statistics and probability theory, parameter estimation. Basic knowledge of multivariate statistics and machine learning is recommended.

Competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

fostered

Problem-solving

assessed

Personal Competencies

Creative Thinking

fostered

Critical Thinking

fostered

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.
Objective

- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

Content

The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Literature


Lecture notes

Moodle platform (enrollment needed)

101-0427-01L Public Transport Design and Operations W 6 credits 4G F. Corman

Abstract

This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system. Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the course is to understand the main characteristics and differences of public transport networks.
Their various performance criteria based on various perspective and stakeholders.
The most relevant decision making problems in a planning tactical and operational point of view
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.
Planning process, from demand evaluation to line planning to timetables to operations Matching demand and modes Line planning techniques Timetabling principles Allocation of resources Management of operations Measures of realized operations Improvements of existing services

Content

Basics for line transport systems and networks Passenger/Supply requirements for line operations Objectives of system and network planning, from different perspectives and users, design dilemmas Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Objectives of system and network planning, from different perspectives and users, design dilemmas Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Lecture notes

Lecture slides are provided.

Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)
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103-0227-00L Application Development in Cartography  
**Abstract**  
This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

**Objective**  
Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design, and implement an interactive and animated 3D web map.

**Content**  
- 3D cartography
- Web mapping
- Data processing
- Animations and interactions
- Map and UI design
- Web application development
- Programming (JavaScript)

**Lecture notes**  
Handouts of the lectures and exercise documents are available on Moodle.

**Prerequisites / notice**  
Cartography II or Introduction to Web Cartography Part 1+2 (MOOC) or similar knowledge in mapping with JavaScript.

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103-0287-00L Image-based Mapping  
**Abstract**  
Application of photogrammetry and remote sensing methods for mapping and Earth observation.

**Objective**  
Learn how to apply photogrammetry, image analysis, and machine learning to mapping tasks; hands-on experience in implementing automatic image analysis methods, and in judging their results.

**Content**  
Preprocessing of satellite images; atmospheric correction; extraction of features (radiometric indices, texture descriptors, etc.) from raw image intensities; semantic image segmentation (e.g., cloud masking); physical parameter estimation (e.g., vegetation height); practical deployment of geometric and semantic computer vision and image analysis methods for mapping; assessment of prediction results

**Prerequisites / notice**  
basic knowledge of photogrammetry, image processing, and machine learning

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102-0617-00L Basics and Principles of Radar Remote Sensing  
**Abstract**  
The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.

**Objective**  
The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation. At the end of the course the student has the understanding of:
1. SAR basics and principles,
2. SAR polarimetry,
3. SAR interferometry and
4. environmental parameter estimation from multi-parametric SAR data
The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:

1. Introduction into SAR basics and principles
2. Introduction into electromagnetic wave theory
3. Introduction into scattering theory and decomposition techniques
4. Introduction into SAR interferometry
5. Introduction into polarimetric SAR interferometry
6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

Lecture notes

Handouts for each topic will be provided

Literature

First readings for the course:

Complete literature listing will be provided during the course.

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<td>Applied Radar Remote Sensing</td>
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<tr>
<td>Abstract</td>
<td>This course provides an introduction to processing and interpreting radar and synthetic aperture radar (SAR) remote sensing data. The primary topics of the course are interferometric techniques and related applications such as topography mapping and mapping of surface displacements, with a strong emphasis on solving practical problems using MATLAB.</td>
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<tr>
<td>Objective</td>
<td>Understand the concepts and techniques required to process and to adequately interpret interferometric radar/SAR data for topographic mapping and surface displacement applications. At the end of the course the student is able to read, display, process, and interpret interferometric radar/SAR data using MATLAB.</td>
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<tr>
<td>Content</td>
<td>The rationale behind the structure of the course follows the idea that radar imaging and radar/SAR interferometry are closely related and that a basic understanding of the radar imaging concept is helpful to understand and interpret interferometric radar data for various applications. The course starts with the real-aperture radar case and a first introduction to the concept of radar interferometry with applications to topographic mapping and mapping of surface displacements. Based on that, the 2-D imaging concept used in synthetic aperture radar imaging is treated. Then, we expand further on radar and SAR interferometric (InSAR) concepts and processing steps for single interferograms and stacks of interferograms also using persistent scatterer interferometry (PSI) to measure deformation based on time series of interferometric SAR data. Finally, the 3-D radar imaging case (SAR tomography) is put into context with PSI/InSAR time series as an extension of the more classical interferometric approaches thereby closing the circle around the strongly related concepts of SAR imaging and interferometry.</td>
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Lecture notes

Additional reading material:

Prerequisites / notice

It is highly recommended that the student has previously taken the following courses:
102-0617-00L: Basics and Principles of Radar Remote Sensing
102-0617-01L: Methodologies for Image Processing of Remote Sensing Data

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<tbody>
<tr>
<td>103-0687-00L</td>
<td>Cadastral Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre, digital twin and related spatial data infrastructures (SDI) as well as their importance for civil society. Students will get an understanding of the conception, structure and impact of cadastral systems and related concepts such as land administration, land registry, PLR-cadastre, spatial data infrastructures and Digital Twins. The link between cadastral systems, gender equality, economic prosperity and the contribution of property cadastre to achieving the United Nation Sustainable Development Goals (UN SDG) is discussed. The Swiss cadastral system (&quot;Amtliche Vermessung&quot;) as well as a number of international systems in developed as well as in developing countries are discussed. The importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Objective     | Origin and purpose of cadastral systems
Importance of documentation of property information as a basis for economic development. Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types) Importance of cadastral systems for societal prosperity due to the impact on the economy, society and the environment. Contribution of the cadastral to the achievement of the UN SDGs on gender equality, poverty and food security. |
| Content       | Swiss cadastral system
- legal basis
- organisation
- Technical implementation
- Quality and integrity assurance
- profession
- Embedding cadastral data in the national spatial data infrastructure |

Literature


---

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1187 of 2667
**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: fostered
- Problem-solving: fostered

**Social Competencies**
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Sensitivity to Diversity: fostered

**Personal Competencies**
- Critical Thinking: fostered

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**851-0724-01L  Real Estate Property Law**

*Particularly suitable for students of D-ARCH, D-BAUG, D-USYS.*

**W 3 credits  3V**

**S. Stucki, R. Müller-Wyss**

**Abstract**
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

**Objective**
The legal principles of real estate property law can be correctly interpreted and applied in daily life.

**Content**
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

**Lecture notes**
Abgegebene Unterlagen: Skript in digitaler Form

**Literature**
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**
- Communication: fostered
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: assessed

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

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**103-0187-01L  Space Geodesy**

**W 6 credits  4G**

**B. Soja**

**Abstract**

**Objective**
After this course, the students should be able to
- Describe the major observation techniques in space geodesy
- Describe the necessary modeling and analysis approaches to derive geodetic products of highest quality
- Select the appropriate space geodetic data for scientific investigations
- Analyze the space geodetic data for scientific purposes
- Interpret the scientific results

**Content**
Overview of GNSS, Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments and observation equations.

Modelling of the station motions and the estimation of station coordinates. Basics of wave propagation in the atmosphere. Signal propagation in the ionosphere and troposphere for the different observation techniques and the determination of atmospheric parameters.

Equation of motion of the unperturbed and perturbed satellite orbit. Osculating and mean orbital elements. General and special perturbation theory and the determination of satellite orbits.

**Lecture notes**
Script M. Rothacher “Space Geodesy”
### Complementary Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0258-00L</td>
<td>Interoperability of GIS</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>J. Schito</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course deepens the understanding of two main interoperability principles used in Geographic Information Science. Students will expand their knowledge of databases and the Swiss standard INTERLIS and will learn to use different tools and mechanisms to transform geodata between different systems: file-based, by web services, or using a model-based approach to define data meaning semantically.</td>
<td></td>
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</tr>
</tbody>
</table>
| **Objective**   | 1. Develop a comprehensive understanding of the key principles of integrability in Geographic Information Science and apply them to geospatial data.  
2. Explore the principles of syntactic and semantic interoperability and apply them to geospatial data using a variety of tools.  
3. Gain an in-depth understanding of geodatabases, UML, INTERLIS, and of the model-driven data transfer with restructuring and apply this knowledge to geodata.  
4. Analyze the ontological spectrum of interoperability principles with varying levels of semantic expressiveness and different formalisms.  
5. Examine the historical development of Geographic Information Systems interoperability, including the evolution of different approaches used across different countries.  
6. Apprehend and foster research skills and improve competences in scientific writing and communication through completion of a voluntary project work. |      |      |       |             |
| **Content**     | The aim of this course is to provide students with a deep understanding of two key interoperability principles in Geographic Information Science. Throughout the course, students will be exposed to a range of tools and mechanisms used to transform geospatial content across different file structures and databases. In particular, we will focus on the Conceptual Schema Language INTERLIS, which is used in Swiss surveying, while developing students' abilities of interpreting, defining, and working with such models, also by using free and open-source tools. Furthermore, we will explore the concept of integrability, which is fundamental to establishing higher levels of interoperability. We will examine how interoperability can span an ontological spectrum from OGC Web Services to semantic transformation, which may one day be understood by machines. By the end of this course, students will have gained a comprehensive understanding of the principles of interoperability and their applications in Geographic Information Science. |      |      |       |             |
| **Prerequisites / notice** | Prerequisites: Completed Bachelor course in GIS II or Geoinformationstechnologien und -analysen (GTA) and familiarity of working with a GIS and with geodatabases. Since we will primarily be using QGIS and PostgreSQL (pgAdmin), it would be beneficial if you could bring your own device with both applications pre-installed. Although not compulsory, it may also be useful to have Python/Anaconda and certain geospatial processing libraries installed. |      |      |       |             |
| Competencies    | Subject-specific Competencies  | Concepts and Theories | assessed  
Techniques and Technologies | assessed  
Method-specific Competencies  | Analytical Competencies | assessed  
Decision-making | fostered  
Media and Digital Technologies | assessed  
Problem-solving | assessed  
Project Management | assessed  
Social Competencies  | Communication | assessed  
Cooperation and Teamwork | fostered  
Self-presentation and Social Influence | fostered  
Sensitivity to Diversity | assessed  
Negotiation | fostered  
Personal Competencies  | Adaptability and Flexibility | fostered  
Creative Thinking | assessed  
Critical Thinking | assessed  
Self-awareness and Self-reflection | fostered  
Self-direction and Self-management | fostered  |

| 103-0778-00L    | GIS and Geoinformatics Lab     | W    | 4    | 4P    | P. Kiefer   |
| **Abstract**    | Independent study project with novel geoinformation technologies. Information on past projects: http://gis-lab.ethz.ch/ |      |      |       |             |
| **Objective**   | This lab focuses on presenting spatial, temporal, and open data in tangible ways. Students will learn how to work with novel geoinformation technologies such as virtual/mixed reality or mobile applications. They will engage in teamwork, application design, programming and presenting their results. |      |      |       |             |
Independent semester work in cartography

The task assignments and selected documentation will be provided as PDF.

Learn to solve engineering problems with modern methods of parameter estimation in a real-world scenario.

Subject-specific Competencies fostered
Choice of theme upon individual agreement fostered
F. Hacklin

This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures.

After attending this course, students will:

1. Understand the fundamentals in theory and practice of entrepreneurship in new technology ventures.
2. Have a clear understanding on how to build mixed reality apps.
3. Have a good overview of state-of-the-art Mixed Reality.
4. Be able to critically analyze and assess current research in this area.

Technological skills increasingly need to be complemented by entrepreneurial understanding.

Success factors in the creation of new firms, including founding, financing and growing a venture.

A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Weekly sessions - recorded.

Prerequisites / notice

- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

Typical lecture format (2h):
15': Introduction
60': Guest testimonial
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Lecture notes
Lecture slides and case material

Competencies
Subject-specific Competencies
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered

Personal Competencies
Creative Thinking fostered
Self-direction and Self-management fostered

263-5905-00L Mixed Reality

Abstract
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

Objective

1. Understand the foundations of Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course is student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Content

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course is student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice

- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

363-0790-00L Technology Entrepreneurship

Abstract
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

Objective

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

Content

Weekly sessions - recorded.

10+ sessions carried out by guest lecturers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...). Final session: multiple choice semester assignment (100% of grade).

Typical lecture format (2h):
15': Introduction
60': Guest testimonial
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Lecture notes
Lecture slides and case material

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered

Personal Competencies
Critical Thinking assessed

103-0787-00L Project Parameter Estimation

Abstract
Solving engineering problems with modern methods of parameter estimation for network adjustment in a real-world scenario; choosing adequate mathematical models, implementation and assessment of the solutions.

Objective

Learn to solve engineering problems with modern methods of parameter estimation in a real-world scenario.

Content

Analysis of given problems, selection of appropriate mathematical models, implementation and testing using Matlab: Kriging; system calibration of a terrestrial laser scanner.

Lecture notes
The task assignments and selected documentation will be provided as PDF.

Prerequisites / notice

Prerequisite: Statistics and Probability Theory, Geoprocessing and Parameterestimation, Geodetic Reference Systems and Networks

103-0747-00L Cartography Lab

Abstract
Independent semester work in cartography

Objective

Independent semester work in cartography

Content

Choice of theme upon individual agreement

Prerequisites / notice

Application Development in Cartography

Further information at http://www.karto.ethz.ch/studium/lehrangebot.html

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1190 of 2667
Analytical Competencies
Project 2
Lecturers fostered
Advanced Geospatial Data Mining and Visualization
Supervisors

Title
This course provides knowledge in advanced methods for extracting and visualizing big geospatial data. Through a combination of lectures, hands-on exercises, and real-world case studies, participants will develop practical skills and knowledge for analyzing and visualizing complex spatial datasets.

ECTS
12 credits

Type
O

Lecturers
M. Usvyatsov

Concepts and Theories
fostered
Techniques and Technologies
fostered

Analytical Competencies
fostered
Decision-making
fostered
Media and Digital Technologies
fostered
Problem-solving
fostered
Project Management
fostered

Communication
fostered
Cooperation and Teamwork
fostered
Customer Orientation
fostered
Sensitivity to Diversity
fostered

Adaptability and Flexibility
fostered
Creative Thinking
fostered
Critical Thinking
fostered
Integrity and Work Ethics
fostered
Self-awareness and Self-reflection
fostered
Self-direction and Self-management
fostered

Personal Competencies

Subject-specific Competencies

Method-specific Competencies

Social Competencies

Supervisors

Prerequisites / notice

Basic probability theory and statistics, linear algebra, basic programming skills

103-0820-00L Introduction to Scientific Computation

W 3 credits

2G

M. Usvyatsov

Introduction to tools, techniques, and methods for data processing and analysis.

Get ready to work with data of different origin. Learn Python and tools to the level which allows attacking data related problems. Basic introduction to numerical algorithms for efficient problem solving.

Python for scientific programming, fast numerical computations and data visualisation.

Lecture slides and related material will be made available in digital form.

The data will be provided to the students within the course.

- Lecture 1: Introduction to the course, objectives, dataset, and exam structure
- Lecture 2: Theoretical background and examples of correlation analysis, event detection, and anomaly analysis
- Lecture 3: Case study 1 – An introduction to the case study. Hands on work on a given task on correlation analysis and visualization.
- Lecture 4: Case study 1 - Hands on work on a given task on correlation analysis and visualization.
- Lecture 5: Case study 1 - Hands on work on a given task on correlation analysis and visualization.
- Lecture 6: Case study 2 - An introduction to the case study. Hands on work on a given task on event detection and visualization.
- Lecture 7: Case study 2 - Hands on work on a given task on event detection and visualization.
- Lecture 8: Case study 2 - Hands on work on a given task on event detection and visualization.
- Lecture 9: Case study 3 - An introduction to the case study. Hands on work on a given task on anomaly detection and visualization.
- Lecture 10: Case study 3 - Hands on work on a given task on anomaly detection and visualization.
- Lecture 11: Case study 3 - Hands on work on a given task on anomaly detection and visualization.
- Lecture 12: Case study 4 - An introduction to the case study. Hands on work on a given task on combination of analysis and visualizations.
- Lecture 13: Case study 4 - Hands on work on a given task on combination of analysis and visualizations.
- Lecture 14: Case study 4 - Hands on work on a given task on combination of analysis and visualizations.

Lecture notes

Literature

Lecture slides and related material will be made available in digital form.

Competencies

Subject-specific Competencies

Concepts and Theories
assessed

Decision-making
assessed

Cooperation and Teamwork
fostered

Creative Thinking
fostered

Self-direction and Self-management
fostered

Social Competencies

Personal Competencies

Introduction to Scientific Computation

Advanced Geospatial Data Mining and Visualization

103-0260-00L Advanced Geospatial Data Mining and Visualization

W 3 credits

2G

C. Zuo, S. Ivanovic

Introduction to tools, techniques, and methods for data processing and analysis.

Acquire the ability to apply spatial analytical methods to heterogeneous spatial data. Familiarity with advanced interactive geodata visualization techniques.

This course will combine lectures and hands-on exercises. Through multiple case studies, students will learn to apply geospatial data analysis and visualization methods through various practical case studies. The students will also be given prepared tutorials and datasets.

Lecture notes

Literature

Lecture slides and related material will be made available in digital form.

Competencies

Subject-specific Competencies

Concepts and Theories
assessed

Decision-making
assessed

Cooperation and Teamwork
fostered

Creative Thinking
fostered

Self-direction and Self-management
fostered

Method-specific Competencies

Social Competencies

Personal Competencies

Project Works

Number
103-0298-10L

Title
Project 1

Type
O

ECTS
12 credits

Hours
24A

Lecturers
Supervisors

Abstract
The projects are supervised by a professorship and teach the students in-depth specialist knowledge in the context of projects to be worked on independently in selected areas of Geomatics, promoting teamwork, project organisation and technical writing and presentation.

Objective
The projects teach the students in-depth specialist knowledge in the context of projects to be worked on independently in selected areas of Geomatics, promoting teamwork, project organisation and technical writing and presentation.

Number
103-0298-11L

Title
Project 2

Type
O

ECTS
12 credits

Hours
24A

Lecturers
Supervisors

Abstract
The projects are supervised by a professorship and teach the students in-depth specialist knowledge in the context of projects to be worked on independently in selected areas of Geomatics, promoting teamwork, project organisation and technical writing and presentation.

Objective
The projects teach the students in-depth specialist knowledge in the context of projects to be worked on independently in selected areas of Geomatics, promoting teamwork, project organisation and technical writing and presentation.

Master’s Thesis

Number
103-0009-10L

Title
Master’s Thesis

Type
O

ECTS
30 credits

Hours
64D

Lecturers
Supervisors

Before starting the Master's thesis, students must have
a. obtained the Bachelor's degree;
b. fulfilled all specified admission conditions, if any;
c. acquired at least 90 credits in the Master's programme, including 12 credits in the area of the interdisciplinary project.

Abstract
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective
To work independently and to produce a scientifically structured work.

Content
The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

> Master Studies (Programme Regulations 2013)

>> Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>103-0009-00L</td>
<td>Master's Thesis</td>
<td></td>
<td>24</td>
<td>51D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective
To work independently and to produce a scientifically structured work.

Content
The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

> Electives

The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

>> Recommended Electives of Master Degree Programme

No course offer.

>> Electives ETH Zurich

Course Catalogue of ETH Zurich

> Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

> Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0132-AAL</td>
<td>Geodetic Metrology Fundamentals</td>
<td>E-</td>
<td>6</td>
<td>13R</td>
<td>J. A. Butt</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the most important sensors, operation and calculation methods of Geodetic Metrology

Objective
Getting to know the most important sensors, operation and calculation methods of Geodetic Metrology

Content
Overview on the different domains of geodetic metrology
Geodetic instruments and sensors
Determination of 3D-coordinates with GNSS, total station and levelling
Calculation methods of geodetic metrology
Survey and staking-out methods

Lecture notes
Slides and additional material used in the associated regular course Geodätische Messtechnik GZ (in German) are provided in electronic form.

Literature
Cartography Fundamentals

Enrollment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Basic knowledge about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.

Objective
Acquire basic knowledge about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well-designed legends for basic maps.

Content
Definitions “map” and “cartography”, map types, current tasks and situation of cartography, map history, spatial reference systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, prepress technology, printing technology, topographic maps, map critiques.

Lecture notes
Will be distributed module by module.

Literature

Parameter Estimation

Enrollment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
This course provides basic knowledge on parameter estimation and data processing. The necessary mathematical and statistical methods are developed and are applied to actual examples in geomatics.

Objective
The students are capable of analysing measurements with appropriate methods. They can optimally extract model parameters from real measurements and are able to analyse and to retrieve additional information from time series. They understand the underlying algorithms of different geodetic analysis tools and processing methods.

Computer Science II

Enrollment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to programming in Java. Procedural foundations of programming and outlook to object-oriented programming. Variables, types, assignments, control structures (branch, loop), data structures, algorithms, line graphs, graphical user interface. Writing small programs. Working with a professional programming environment (Eclipse).

Objective
In the course “Computer Science II”, the competencies of programming, modeling and data analysis & interpretation are taught, applied and examined. The students will be able to write simple programs and to modify existing programs.

Content
This course offers an introduction to variables, control structures (branch, loop), algorithms and data structures, as well as an outlook to modularisation and object-oriented techniques. In the exercises students train programming skills (in the programming language JAVA); Students can solve the exercises on their own laptop or in the computer labs at ETH. The software used in this course runs on MS Windows, MacOS X and Linux.

Linear Algebra

Enrollment ONLY for MSc students with a degree declaring this course unit as an additional admission requirement.

Abstract
This course offers an introduction to variables, control structures (branch, loop), algorithms and data structures, as well as an outlook to modularisation and object-oriented techniques. In the exercises students train programming skills (in the programming language JAVA); Students can solve the exercises on their own laptop or in the computer labs at ETH. The software used in this course runs on MS Windows, MacOS X and Linux.

Prerequisites:
252-0845-00 Computer Science I (D-BAUG)
Abstract
Introduction to Linear Algebra

Objective
Basic knowledge of linear algebra as a tool for solving engineering problems.
Understanding of abstract mathematical formulation of technical and scientific problems.

Content
Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces.

Literature

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed, Problem-solving assessed
Personal Competencies: Critical Thinking fostered

406-0242-AAL  Analysis II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Mathematical tools of an engineer

Objective
Mathematics as a tool to solve engineering problems, mathematical formulation of problems in science and engineering. Basic mathematical knowledge of an engineer.

Content

Literature
Textbooks in English:
- J. Stewart: Multivariable Calculus, Thomson Brooks/Cole
- V. I. Smirnov: A course of higher mathematics. Vol. II. Advanced calculus
- M. Akveld, R. Sperb, Analysis II, vdf
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

406-0243-AAL  Analysis I and II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems. Mathematical formulation of technical and scientific problems. Basic mathematical knowledge for engineers.

Content
Complex numbers.
Calculus for functions of one variable with applications.
Simple Mathematical models in engineering.

Literature
Textbooks in English:
Textbooks in German:
- M. Akveld, R. Sperb: Analysis I, vdf
- M. Akveld, R. Sperb: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

406-0603-AAL  Stochastics (Probability and Statistics)
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language “R.”
Content

From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 4: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R" (online)
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435
  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed

Personal Competencies
Self-direction and Self-management assessed

406-0062-AAL Physics I
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts in mechanics.

Content
Book:
Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature
see "Content"

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed

Personal Competencies
Self-direction and Self-management assessed

406-0063-AAL Physics II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to the "way of thinking" and the methodology in Physics. The Chapters treated are Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

Content
Book:
Chapters:
Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003
4th edition 2022

Competencies

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<tr>
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252-0856-AAL Computer Science
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

Objective
Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.

Content
The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

Lecture notes
Lecture slides and all other material will be made available for download on the course web page.

Literature
Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000

Competencies

<table>
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<tr>
<th>Competency Type</th>
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<th>Social Competencies</th>
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<td>Self-presentation and Social Influence</td>
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103-2233-AAL GIS Basics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Fundamentals in geoinformation technologies: database principles, including modeling of spatial information, geometric and semantic models, topology and metrics; practical training with GIS software.

Objective
Know the fundamentals in geoinformation technologies for the realization, application and operation of geographic information systems in engineering projects.

Content
Modelling of spatial information
Geometric and semantic models
Topology & metrics
Raster and vector models
Databases
Applications

Literature
<table>
<thead>
<tr>
<th>Module Code</th>
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<th>Instructor</th>
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<td>103-0187-AAL</td>
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<td>4</td>
<td>3R</td>
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<td><strong>Objective</strong></td>
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<td>Understanding the major observation techniques in space geodesy as modern methods applied in Earth system monitoring (geometry, rotation and gravity field of the Earth and the atmosphere), in national surveying and navigation.</td>
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<td><strong>Content</strong></td>
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<td>Script M. Rothacher “Space Geodesy”</td>
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<td><strong>Abstract</strong></td>
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<td>Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.</td>
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<td>Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.</td>
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<td>- Unit Step Function, t-Shifting</td>
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<td>- Short Impulses, Dirac's Delta Function, Partial Fractions</td>
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<td>- Convolution, Integral Equations</td>
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<td>- Differentiation and Integration of Transforms</td>
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<td>- Even and Odd Functions, Half-Range Expansions</td>
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<td>- Fourier Integral</td>
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<td>Partial Differential Equations:</td>
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<td>- Modeling: Vibrating String, Wave Equation</td>
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<td>- Solution by separation of variables; use of Fourier series</td>
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<td>- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series</td>
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<td>- Solution of PDEs by Laplace Transform</td>
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<td>For reference/complement of the Analysis I/II courses:</td>
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<td></td>
<td>Christian Blatter: Ingenieur-Analyse (Download PDF)</td>
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<td>Earth Observation</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1197 of 2667
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

Objective
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:
1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

103-0849-AAL Multivariate Statistics and Machine Learning
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to statistical modelling and machine learning.

Objective
The goal is to familiarise students with the principles and tools of machine learning, and to enable them to apply them for practical data analysis.

Content
multivariate probability distributions; comparison of distributions; regression; classification; model selection and cross-validation; clustering and density estimation; mixture models; neural networks

Literature
- Hastie, Tibshirani, Friedman: The Elements of Statistical Learning, Springer 2009
- Duda, Hart, Stork: Pattern Classification, Wiley 2012

Geomatics Master - Key for Type

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<td>Compulsory</td>
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<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
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<td>Dr</td>
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Key for Hours

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<td>seminar</td>
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<td>colloquium</td>
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ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
History and Philosophy of Knowledge Master

Basic Courses

Lectures and Exercises

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<tr>
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<td>851-0360-00L</td>
<td>The Tower of Babel: From Babylon to Babel Fish</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>P. Gerard</td>
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<tr>
<td>862-0050-00L</td>
<td>Theory and Methodology MAGPW</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>T. Bartoletti, N. Kirchner, D. Lucas</td>
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<tr>
<td>853-0725-00L</td>
<td>History Part One: Europe (The Cradle of Modernity, Britain, 1789-1914)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>H. Fischer-Tiné</td>
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</table>

Objective

- To practice inter- and intra-linguistic translation and confront the problem of "the untranslatable."
- To situate contemporary discussions of machine translation in relation to earlier literary and philosophical reflections on the problem of linguistic diversity.
- To gain familiarity with historical origins of machine translation and the stages of its development until the present.
- To draw historical, thematic, and conceptual connections between the emergence of machine translation in the middle of the twentieth century and the impulses driving post-war literary and theoretical texts.
- To apply information theory to the analysis of literary texts.

Competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered
- Method-specific Competencies
  - Analytical Competencies: fostered
  - Media and Digital Technologies: fostered
- Social Competencies
  - Communication: assessed
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: fostered
- Personal Competencies
  - Creative Thinking: fostered
  - Critical Thinking: fostered
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered

Abstract

"Will the vocabularies never cease clashing/Werden die Wörterbücher immer streiten/Will the bickerwords never grow silent."
- Eugene Jolas, "Babel: 1940"

Date: 02.07.2024 12:39
Autumn Semester 2024
Page 1199 of 2667
Biomedical engineering is a significant field, encompassing various ethical issues related to life and death, e.g. reproductive technology, euthanasia, organ transplantation, genetic engineering, human enhancement, animal welfare, biodiversity and our relation to nature more generally. Biomedical ethics is addressed in various contexts and disciplines, in politics, in law, in religious contexts, in the social sciences, religious studies, medicine and the biosciences. The focus in this course is on the fundamental debates in ethics as a philosophical discipline. In addition, topics are discussed for discussion depending on the students' interests.

### Literature


### Competencies

#### Subject-specific Competencies
- Concepts and Theories: fostered
- Analytical Competencies: fostered
- Decision-making: fostered
- Communication: fostered
- Cooperation and Teamwork: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered

#### Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Communication: fostered
- Cooperation and Teamwork: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered

### Content

This course will review several case studies from the ancient, medieval and modern history of mathematics. The case studies will be analyzed from various philosophical perspectives, while situating them in their historical and cultural contexts. The course aims are:

1. To introduce students to the historicity of mathematics
2. To make sense of mathematical practices that appear unreasonable from a contemporary point of view
3. To develop critical reflection concerning the nature of mathematical objects
4. To introduce various theoretical approaches to the philosophy and history of mathematics
5. To open the students' horizons to the plurality of mathematical cultures and practices

#### Competencies

- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Sensitivity to Diversity: fostered
- Critical Thinking: fostered

### Prerequisites / notice

Elementary knowledge of formal presentation of systems, as well as an interest in the interdisciplinary verification of knowledge.

### Data

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- Autumn Semester 2024
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Knowledge about Past Mass Atrocities

Abstract
The course deals with the scientific production of knowledge about past mass atrocities. It looks at the interplay of different disciplines, methods and technological means that have been involved in this production over time. Further, it poses the question of what truth can mean in this context.

Objective
The students a) know the main features of the discussion about the truth in the reconstruction of past events; b) have an understanding of the interplay, but also the coexistence of different scientific methods and technological means in the multidisciplinary production of knowledge about past mass crimes; c) have knowledge of important processes of dealing with past mass crimes from the second half of the 20th century onwards.

Content
When discussing the truthfulness of the academic study of the past, politically and ideologically motivated mass crimes are often cited as historical events in order to substantiate the necessity of a claim to truth. In doing so, moral arguments can be made or historical truth can be asserted as a basic prerequisite for living together in a democratic society under constitutional conditions.

The production of knowledge about past atrocities has always been an endeavour in which various scientific disciplines have been involved. The multidisciplinary character of the production of knowledge about mass crimes has become even more accentuated since the second half of the 20th century, not least due to the emergence of new technological possibilities.

The course offers a brief introduction to the discussion about the meaning of truth also past events. It looks at how different scientific approaches - from the humanities to the natural sciences - have been involved in coming to terms with mass crimes and how they have been related to each other. It deals with the question of what role certain techniques and technologies have played in the production of knowledge about past atrocities and how this has changed over time. These techniques and technologies range from the evaluation of documents and the taking of testimonies to specialised database programs, genetic analysis or imaging techniques, to digital technologies for the procurement of information on social media and the internet or for the modelling of past events.

In addressing these questions, the course looks at processes of dealing with the past from the middle of the 20th century to the 21st century in Europe, Latin America and Africa.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Critical Thinking

Personal Competencies
- fostered
- assessed

851-0020-00L Gender and Science

Objective
This lecture series offers an introduction to the relationship between gender and science, with a focus on the specific intersections with the sciences taught at ETH.

Content
There is agreement across academic disciplines today that gender influences and structures the production of knowledge and that scientific knowledge production in turn shapes gender notions. Even within "hard" sciences such as mathematics, physics, engineering, etc., gender is a significant factor in determining what counts as "objective" knowledge, who can know it, what kind of knowledge is produced, or how this knowledge is acquired and justified. Feminist research aims to reveal how dominant conceptions of science and knowledge practices disadvantage women, and other subordinate groups, with the goal of reforming these practices. An important part of feminist critique is to show that such efforts substantially improve the overall quality of research.

The semester will start with two introductory lectures acquainting students with research questions in the field of Gender and Science by summarizing its key concepts and methods. It will then continue as a series of weekly guest lectures by scholars from different scientific disciplines that provide accessible insights into the intersection between gender studies and the guest lecturer’s research field. Students will thereby be encouraged to learn from concrete examples rather than abstract theory. The goal is for students to understand how to apply concepts and methods of gender studies to their particular disciplines. Intermediate discussions with the students will provide a forum for critically reflecting the content of the lectures and the connections to their own academic fields and practices.

All lectures by the guest speakers will also be open to the broader ETH public, while the introductory and discussion sessions are only for registered course participants.

851-0157-28L Life and Death

Abstract
This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Objective
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy — but also in the life sciences, such as biology and medicine. Questions regarding health and well-being, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0202-00L Digital Humanities: Methods, Challenges, Perspectives

Abstract
In the 21st century, the humanities and the social sciences are undergoing a ground-breaking transformation: Data-driven, collaborative projects open up new opportunities. Which are the promises and the challenges of digital methods? The lecture series provides an overview of the latest developments.

Objective
- exploring the most important theoretical and methodological approaches since 2000
- understanding terms and procedures — using digital texts, images and metadata
- reflecting on the conditions, opportunities and problems of digital methods

Content
The possibilities (Franco Moretti, Graphs, Maps, Trees, Verso 2005; Andrew Piper, Enumerations, Chicago UP 2018) and pitfalls (Franco Moretti, The Wrong Move, Konstanz UP 2022) of cultural history under digital conditions require critical reflection and evaluation. The lecture will explore showcases and pioneering work, annotated texts, images, metadata and interfaces provided by libraries, archives and museums. Research approaches and practical applications will be presented and evaluated.

851-0527-00L Introduction to the History of Technology: Concepts, and Current Debates

Abstract
Technology and society cannot be separated: No society functions without technology. The seminar offers a problem-oriented introduction to basic questions of the history of technology, introduces approaches to the history of technology and discusses selected, ongoing debates.

Objective
The course seeks to provide a critical introduction to the issues, methods, and selected areas of research in the history of technology.
History of technology investigates technological developments that arise in specific historical contexts. These developments are perceived by social groups or entire societies as a means of social change and ultimately find use or are forgotten. The questions that history of technology poses derive from the technological and social change that are a product of contemporary orientation and thinking; current historiographical methods provide the tools for answering these questions.

851-0453-00L

**Artificial Intelligence and Human Values**

- **W** 3 credits 2G
- **M. Boenig-Liptsin**, K. Wodajo

**Abstract**

This course introduces students to the ethical, political and legal debates and transformations in relation to Artificial Intelligence and provides students with concepts and methods from the constructivist and interpretive social sciences to work towards responsible and democratic human-technology futures.

**Objective**

The main objectives of the course are to enable students to 1) identify the ways in which human values and developments of AI technologies are entangled, 2) articulate what is significant about contemporary transformations in AI and society, and 3) participate and shape the relationship between human values and AI as citizens and professionals.

**Content**

The growing presence of AI tools for public use, for public administration, inside corporations and in scientific research raises many questions about the ethical, political, legal consequences of these technologies. This course is built around multiple sites of encounter among human values and AI, including bodies, persons, cities, labs, law, and environment. In each site, we inquire about what and whose values are being prioritized and with what consequences. The course also investigates existing best-practices around how to “align” human values with AI (e.g. human-centric design, alignment, reproducibility, transparency, explainability) and introduces students to regimes of ethics and governance of AI being proposed in jurisdictions around the world. Students learn to unpack the values and assumptions in existing techniques and frameworks for the design and governance of AI and to engage constructively with diverse stakeholders to shape the human-technology future towards aims that are reflexive, responsible, and democratic.

851-0297-00L

**Manipulation in Literature and Cultural History**

- **W** 3 credits 2V
- **S. S. Leuenberger**

**Abstract**

This lecture focuses on the manipulation and control of individuals and the masses. The power of manipulation is based on subtle use of persuasive linguistic elements and knowledge of the desires and fears of the intended audience. In addition to a theoretical overview, the lecture concentrates on the literary and discursive texts that dispute the control of protagonists.

**Objective**

Students will learn about manipulation as a linguistic and narrative phenomenon steeped in myth and classical rhetoric. Against the backdrop of cultural-historical developments, particularly with regard to major changes in media technology, we will examine how the reach of manipulation was extended from the individual to the masses. Students will be able to refine their critical discourse analysis skills and interdisciplinary abilities by studying texts from literature, politics, sociology, philosophy and psychoanalysis which reflect this shift in emphasis.

**Content**

Since the dawn of time mankind has tried to exert influence over others through the utilisation of certain techniques: initially for self-preservation – for example the interpretation of Sigmund Freud in Totem und Tabu. Later, desire became the driving force – centre stage: the desire for pleasure, power and control. Manipulation manifests itself in the form of characters and words, it is an authentically linguistic occurrence: classical antiquity, with the rhetoric, develops a system of verbal power of persuasion and, already then, questions were being raised in literary and discursive texts about how people could, or even should, manipulate. The exertion of influence and its impact will be clearly described, propagated, commented upon, criticised and ironised. In contrast to oppressive overpowering, the power of manipulation (in Latin, manus hand, plere fill) is on the one hand, based on the subtle use of persuasive linguistic elements – it is always a (literary) discourse, too – and on the other, on knowing precisely what the fantasies, desires and fears of the manipulated are. The discourse of manipulation has its beginnings in the age of sophists and their belief in an omnipotence of language and rhetoric. It underwent further transformation under political and psychological signs in the early modern period through Giordano Bruno and Niccolò Machiavelli and culminated in the 20th century in a critique of the deception strategies of the “culture industry” (T.W Adorno) and “psychotechnology” (B. Stiegler) in global capitalism. Nowadays social media is the “radicalisation machine” (J. Ebner) that present new challenges for society. Written in the 19th century, the Protocols of the Elders of Zion already gave indications of how present-day conspiracy theorists would manipulate their audience, and its impact can still be felt today. Since manipulation is a linguistic, narrative and also literary phenomenon, the central theme of the lecture is how in literature itself this often politically controversial and manipulative behaviour is picked up and reflected through poetry: such as in Tristan from Gottfried von Strassburg, Goethe’s Wilhelm Meister, Friedrich Schiller’s Die Verschwörung des Fiesco zu Genua or Heinrich von Kleist’s Der zerbrochene Krug, the works of Edgar Allan Poe and Thomas Mann (Mario und der Zauberer) and, most recently in Eckhart Nickel’s novel, Hysteria.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories fostered
  - Techniques and Technologies fostered
- **Method-specific Competencies**
  - Analytical Competencies fostered
  - Decision-making fostered
  - Media and Digital Technologies fostered
  - Problem-solving fostered
- **Social Competencies**
  - Communication fostered
  - Cooperation and Teamwork fostered
  - Sensitivity to Diversity fostered
  - Negotiation fostered
- **Personal Competencies**
  - Adaptability and Flexibility fostered
  - Creative Thinking fostered
  - Critical Thinking fostered
  - Integrity and Work Ethics fostered
  - Self-awareness and Self-reflection fostered
  - Self-direction and Self-management fostered

**Seminars**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
701-0019-00L | **Readings in Environmental Thinking** | W | 3 credits | 2S | J. Ghazoul

**Abstract**

This course introduces students to foundational texts that led to the emergence of the environment as a subject of scientific importance, and shaped its relevance to society. Above all, the course seeks to give confidence and raise enthusiasm among students to read more widely around the broad subject of environmental sciences and management both during the course and beyond.

**Objective**

The course will provide students with opportunities to read, discuss, evaluate and interpret key texts that have shaped the environmental movement and, more specifically, the environmental sciences. Students will gain familiarity with the foundational texts, but also understand the historical context within which their academic and future professional work is based. More directly, the course will encourage debate and discussion of each text that is studied, from both the original context as well as the modern context. In so doing students will be forced to consider and justify the current societal relevance of their work.
The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is not a scientific paper) to identify the key points for discussion.

Thereafter, in each week a text (typically a chapter from a book or a paper) considered to be seminal or foundational will be assigned by a course lecturer. The lecturer will introduce the selected text with a brief background of the historical and cultural context in which it was written, with some additional biographical information about the author. He/she will also briefly explain the justification for selecting the particular text.

The students will read the text, with two to four students (depending on class size) being assigned to present it at the next session. Presentation of the text requires the students to prepare by, for example:

- identifying the key points made within the text
- identifying issues of particular personal interest and resonance
- considering the impact of the text at the time of publication, and its importance now
- evaluating the text from the perspective of our current societal and environmental position

Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

The specific texts selected for discussion will vary, but examples include:

- Jared Diamond (2005) Collapse
- I. Günther

Discussions might also encompass films or other forms of media and communication about nature.

Competencies

Subject-specific Competencies

- Concepts and Theories: fostered

Method-specific Competencies

- Media and Digital Technologies: fostered

Social Competencies

- Communication: assessed
- Cooperation and Teamwork: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: assessed

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

<table>
<thead>
<tr>
<th>851-0039-00L</th>
<th>Plural Perspectives on Rationality</th>
</tr>
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<tbody>
<tr>
<td>Abstract</td>
<td>Rationality has been treated as a &quot;universal&quot; character of human beings. But such understandings, though dominant, also came under androcentric and Eurocentric critiques. They point out that exclusion of women and people of color is not aberrant bad scientific practices, but rather constituent of the principle modern science based on. This seminar offers plural perspectives on rationality.</td>
</tr>
<tr>
<td>Objective</td>
<td>The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is not a scientific paper) to identify the key points for discussion.</td>
</tr>
<tr>
<td>Content</td>
<td>Understand as a distinctive human attribute, rationality has been treated as a &quot;universal&quot; character of human beings. But the course of philosophy has witnessed how dominant understandings of rationality came under androcentric and Eurocentric critiques. Such reflections argue that exclusion of women and people of color is constituent of the principle modern science is based on rather than aberrant bad scientific practices.</td>
</tr>
</tbody>
</table>

851-0622-00L

| Abstract | Globalization and technological progress in recent decades have on the one hand reduced inequality and led to new forms of inequality on the other hand. The question is whether these new forms of inequality lead to more inequality. This course provides an overview of the current philosophical and economic discourse on inequality and injustice. |
| Objective | Using philosophical and economic texts and discussions, students develop an understanding of the concepts, developments, causes, and consequences of inequality. Students will acquire the ability to participate in an informed discourse on the issues of inequality and injustice and to critically reflect on their actions and position in the world. |
Content
In this seminar we will explore the issues of inequality and injustice. In doing so, we will explore the following questions: What is meant by inequality and injustice? Under what circumstances are inequalities unjust? Have inequalities and injustices increased or decreased over the last 50 years? What are the causes of increasing or decreasing inequality? What do these inequalities and injustices mean for our society? And what public and private measures are needed for more inclusive societies?

- Concepts of inequality and injustice
- Development of inequality over the last 50 years based on different dimensions of inequality: income, wealth, education, health, CO2 emissions, political participation
- Discrimination of women, people with physical disabilities, people of the "Global South"
- Causes of inequality: globalization, technological progress, political systems and institutions, economic system, social discrimination, stereotypes and norms.
- Consequences of inequality: justice, dignity, inefficiency
- Towards more inclusive societies: the role of policies, civil society, social movements and individual behavior.

The seminar is based on readings of economic and philosophical texts and is complemented by short presentations and discussions with scholars of philosophy and economics. In some cases, practitioners will also be invited to the seminar. Students will apply the concepts, theories and knowledge covered in the course to practical issues related to inequality and inequity.

862-0122-00L
Science and Mysticism

Abstract
Mysticism and science appear to be the greatest possible opposites: mysticism is based on the abandonment of knowledge, science on the overcoming of mysticism. Yet in fact, there are far-reaching connections between the two: skepticism, language criticism, experience, subjectivity, ecstasy, anarchy. We want to examine these using texts from medieval as well as modern neo-mysticism.

Objective
At first glance, mysticism and science appear to be the greatest possible opposites: mysticism is based precisely on the abandonment of knowledge, whereas science is based on overcoming mysticism. However, upon closer inspection it becomes clear that there are different and far-reaching mediations between the two. Because what characterizes the mysticism developed in different religions in the Middle Ages (if it can even be defined in general terms) is the criticism of a certain, namely dogmatic, knowledge, in contrast to which something that seems surprisingly modern is emphasized: subjective experience. The emphatic theory of experience, the subject (and its dissolution), but also language (and its criticism) are among the reasons for the rediscovery of mysticism in modern times around 1900 in philosophy and literature, in science and politics. In the MAGPW seminar we will examine the complex relationship between mysticism and science, using theoretical problems, including "negative theology" and anti-science (ignorance), (radical) skepticism, language criticism, experience, subject dissolution, ecstasy, anarchy. We start from concrete texts, on the one hand from the interreligious spectrum of medieval mysticism (such as Eckhart, Abulafia, Al-Gazzali), and on the other hand and above all from modern neo-mysticism around 1900 (such as Gustav Landauer, Martin Buber, Wittgenstein, Robert Musil, Hermann Broch).

Competencies
Subject-specific Competencies
- Concepts and Theories fostered
- Analytical Competencies fostered
- Project Management fostered

Method-specific Competencies
- Communication fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered

Social Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

851-0037-00L
Ethics of Building

Abstract
Building practices have often been associated with utopian visions and promises of a more just way of living together. But to what extent can the built environment contribute to a better society? What role can mathematical models or data analyses play in questions of distributive justice in the city? Is it ever possible to build sustainably, or is building always also destroying the environment?

Objective
Students will learn about contemporary debates in architectural and urban planning ethics. We will discuss the positions against the background of their historical predecessors and current contexts. Students will work on small case studies in which they will ethically analyze the construction of a building, a district or a city. The seminar includes a student-co-led expedition through Zurich.

Content
Throughout history, there have always been utopian visions and promises tied to construction, be it of individual objects, such as towers, or entire cities. For example, thanks to their geometric shapes, modern cities are supposed to enable more equality among people, even the equal distribution of sunshine, as Le Corbusier once dreamed. But to what extent is it even possible to create more equality by designing living spaces? A wall automatically excludes by protecting the interior. Building cities always means defining the far and the near, the equal distribution of sunshine, as Le Corbusier once dreamed. But to what extent is it even possible to create more equality by designing living spaces? A wall automatically excludes by protecting the interior. Building cities always means defining the far and the near, commute far and those who are at the center of the action. Who determines how and what is built and whose perspective is not taken into account? To whom does a built landscape afford agency and to whom not? Mathematical models can predict the probabilities of encounters in space, which also can have an impact on social relationships. What is the relevance of such models as well as the more recent data analyses in questions of distributive justice? Is it possible to distribute social participation in the city? Does construction always have to destroy and replace the underlying nature? How do our building practices affect coexistence with other species?

We will not be able to solve these problems in one semester, but we will intensively grapple with the overarching question implied in all of them. The question is on the extent to which the built environment takes on ethical significance for human (and other) forms of life, and how are we to understand ethics in general if it is to respond to such questions.

Competencies
Subject-specific Competencies
- Concepts and Theories fostered
- Analytical Competencies fostered
- Project Management fostered

Method-specific Competencies
- Communication fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered

Social Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

851-0067-00L
Science Studies between economic growth, social needs and critique

Abstract
Science has become a subject of research in its own right since the 20th century: the field of "science studies" examines the organization of science, its social benefits, its contribution to economic growth or its impact on people and nature. The seminar introduces the history of this research and sheds light on its applied and critical dimensions.

Objective
Using historical sources from the field of science studies, students learn to understand societal expectations and criticisms of the sciences in the 20th and 21st centuries.
The value of science for social and economic development has been an issue of debate since the 20th century. At the same time, science became a subject of research in its own right: the sociology of science in the 1930s dealt with the social benefits (“Science for Social Needs”) and the organization of science. Since the 1950s, the research field of the “Science of Science” has quantified scientific publications (“Science Citation Index”) and attempted to measure the relationship between research and innovation, between education and economic growth (OECD studies). Science seemed to promise scientific and technical progress, innovation and economic growth - both in the industrialized countries and, with the help of “technology transfer”, to the then so-called “developing countries”. At the same time, in the field of “technology assessment”, the sciences were criticized for causing risks and damages to humans and nature (e.g. through pesticides or biotechnology) or entailing effects of social inequality.

The fact that the sciences have been the subject of debate since the 20th century is not only a matter of general public interest. It is also the effect of the development and funding of research fields that deal with measures to increase innovation or with the benefits and risks of science. The seminar deals with the history of this research in its political and economic contexts as well as in its applied and critical function. It examines the knowledge on which historical and current expectations of science in politics and society are based.

**Literature**

Sources (selection):
- J.D. Bernal: "The Social Function of Science" (1939)
- Derek de Solla Price: "Little Science, Big Science" (1963)
- Hilary Rose & Steven Rose: "Science and Society" (1969)
- Christopher Freeman: "Economics of Research and Development" (1977)
- Ziauddin Sardar, Dawud G. Rossier-Owen: "Science Policy and Developing Countries" (1977)
- Donna Haraway: "Class, Race, Sex, Scientific Objects of Knowledge" (1982)

Secondary literature (selection):
- Gerardo Ienna: "The Double Legacy of Bernalism in Science Diplomacy" (2022)
- Elena Aronova: "Scientometrics with and without Computers: The Cold War Transnational Journeys of the Science Citation Index" (2016)
- Elena Aronova & Simone Turchetti: "Science Studies During the Cold War and Beyond" (2017)
- Ariane Leendertz: "Finalisierung der Wissenschaft". Wissenschaftstheorie in den politischen Deutungskämpfen der Bonner Republik (2013)

**Competencies**

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies

Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Social Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics

Personal Competencies
- Creative Thinking
- Self-awareness and Self-reflection

<table>
<thead>
<tr>
<th>851-0281-00L</th>
<th>The Knowledge of Poetry</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>C. Jany</th>
</tr>
</thead>
</table>

Abstract: Novalis once described poetry as "the mind's inherent way of acting". Thinking takes place in verses and images, rather than concepts and formulas. If this were true, every spontaneous cognition would amount to poetry and each thought essentially to a poem -- a structure combining and concentrating ideas, perceptions, and emotions. Knowledge and poetry would be one.

Objective: Such is the promise literature has made since its inception, a promise we will examine in this class by considering mainly lyrical compositions in verse, from the beginnings to the present. The central question is: What do poems know and what is the relationship between thinking in verse and technical and scientific knowledge?

<table>
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<tr>
<th>851-0077-00L</th>
<th>Philosophy of War</th>
<th>W</th>
<th>3 credits</th>
<th>2S</th>
<th>O. Del Fabbro</th>
</tr>
</thead>
</table>

Abstract: In the course we read classical texts from the field of philosophy of war (Clausewitz, Sun Tzu, Tolstoy, Machiavelli, Kant) and focus on questions such as: what is war? Strategy and tactics in war? Ethics of war? War and Politics?

Objective: Students learn about the different types of argumentative texts and their historical, social, political and ethical context. They learn to understand the descriptive and critical value of texts in regard to the topic of war.

<table>
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<tr>
<th>851-0019-00L</th>
<th>Insect Histories: Bugs that Made the Modern World</th>
<th>W</th>
<th>3 credits</th>
<th>2S</th>
<th>T. Bartoletti</th>
</tr>
</thead>
</table>

Abstract: The seminar explores insects as historical actors and their diverse interactions with human societies over time and space. It offers an overview of recent approaches in environmental history and multispecies ethnography while providing an analytical framework to understand global processes of natural resource exploitation, knowledge formation, and imperialism.

Objective: The objective is to analyze human-insect interactions by identifying key historical factors (economic, scientific, political). Students will integrate current frameworks in the study of environmental history through the combination of primary sources and interdisciplinary research. They will develop skills rooted in their interest in insects and learn to translate them into feedback to peers.

Content: Scholars typically approach Nature-related histories by focusing on environmental change, the commodification of resources, and the legacy of natural history collections. Examples of this approach include studies on deforestation, dam constructions, the rubber boom, and the colonial history of European museums. In contrast to these commonly explored topics, insects are often underrepresented in historical research, both as living creatures and metaphors. Addressing this gap, the seminar explores human-insect interactions from a global historical perspective between 1600 and 2000. This exploration encompasses a critical and relational understanding of the history of the scientific study of insects (entomology) and the processes of imperial expansion and global territorialization. To achieve this, students will learn how human-insect interactions led to radical transformations in diverse environments, reflecting a particular modern conception of nature influenced by control anxieties related to economic profit and tropical diseases. Moreover, students will examine how ways of knowing about insects and the environment were influenced by broader correlated economic and imperial factors. Focusing on insect (hi)stories, the aim of this seminar is to apply new methodologies for non-human agencies and source analysis on both micro and macro scales in global and environmental histories.

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<thead>
<tr>
<th>851-0304-00L</th>
<th>Science Fiction</th>
<th>W</th>
<th>3 credits</th>
<th>2S</th>
<th>A. Kilcher, S. Lohmann</th>
</tr>
</thead>
</table>

Abstract: Literature in general can be seen as fundamentally concerned with the forms and functions of knowledge and (sometimes scientific) understanding, but the genre of science fiction is unique in that it literalises this approach in a far-reaching fashion as the future of science and technology. We will explore knowledge, and the "science of literature" through a diverse range of science fiction texts.

Objective: - Concept and history of science fiction
- Theory of science fiction and related forms (e.g. utopia, fantasy)
- Contexts of the history of knowledge and technology in the 19th and 20th centuries.
- Potential of science fiction to criticise technology and society
This course introduces students to the various forms and functions of knowledge and science in literature, particularly within the realm of science fiction, the genre that most directly epitomizes this fundamental connection within literary texts. In analysing how it shifts our understanding of ourselves and of supposedly inalterable facts about the reality we inhabit, we will examine how science fiction demonstrates that fiction is neither fundamentally in conflict with scientific knowledge, as previously supposed, nor a mere vehicle for its celebration, as still commonly presumed of science fiction. Instead, the genre, with its radical investigations into other forms of being, fearing and hoping, plays a crucial role in the social formation, order and negotiation of knowledge. As such, science fiction also represents a vital thought experiment regarding the “science of fiction”, i.e. the development of a knowledge of literature and the many fascinating ways in which it helps us to know our own world better, in turn.

In this course, we will take a systematic and theory-based approach to a deeper understanding of science fiction, particularly concerning its historical background, unique aesthetic/narrative tools, and relationship with the critical and technocultural contexts that shape it. Employing contemporary theoretical approaches, we will discuss a variety of themes within primary texts alongside diverse critical sources, all of which ultimately relate to knowledge and knowability. Particular areas of focus may include: other worlds and alien existences; altered temporality and alternate history; utopias and dystopias; climate fiction and the Anthropocene; posthumanist and cyborg identities; robots and AI; and alternative futurisms. Moreover, the course will thereby also engage with the fundamental (and at times overlooked) role of order and presentation of knowledge, i.e. its aesthetic and narrative forms, within science and literature.

851-0456-00L

**Research in Ethics, Technology and Society**

- **Objective**: The objective of the course is to provide students doing their own research on topics in science, technology and society with focused peer-feedback and tailored theoretical and methodological discussions to support the development of their projects.

- **Competencies**
  - Subject-specific Competencies
    - Concepts and Theories
  - Method-specific Competencies
    - Analytical Competencies
  - Social Competencies
    - Communication
  - Personal Competencies
    - Adaptable and Flexible
    - Critical Thinking
    - Self-awareness and Self-reflection

- **Abstract**: Through thematic discussions of readings, presentation and workshopshopping of writing-in-progress, and discussions with invited guests, this course brings together advanced students doing research in science, technology and society to develop their knowledge and projects in community with peers, postdoctoral fellows, and faculty.

851-0455-00L

**Science, Trust and Politics**

- **Objective**: The seminar aims to inspire a nuanced understanding of the dynamics of expertise in society. Cross-fertilizing literature from science and technology studies (STS) and from activists' movements, it focuses on contemporary controversies around emerging technologies and climate policy, where trust in science is said to be undermined (e.g. climate skepticism or anti-vaccine movements).

- **Competencies**
  - Subject-specific Competencies
    - Concepts and Theories
  - Method-specific Competencies
    - Analytical Competencies
  - Social Competencies
    - Communication
  - Personal Competencies
    - Adaptable and Flexible
    - Critical Thinking
    - Self-awareness and Self-reflection

- **Abstract**: Engineers and scientists often pursue their studies and research in the hope that their knowledge can contribute to make a better world, inform democratic deliberation and help public understanding of complex issues. Yet this special status of science and technology is being increasingly contested by marginalized publics, lobbies, exposed populations, and by members of the scientific communities themselves. Climate skepticism or vaccine hesitancy are some of the most vivid examples of this confusing situation. In this seminar, students will learn to reflect on expertise as a form of scientific engagement in the messiness of democratic deliberation and public life, beyond the noble but outdated ideal of “speaking truth to power”.

- **Content**: The exercise of expertise is stumbling upon several conundrums. Which knowledge is relevant in which situation? How to make sure that some crucial perspectives are not left in the shadows? How to identify representative experts and make sure that they speak on behalf of a structured community? Whose voices are being silenced? On the other side of the spectrum, the public is often said to lack proper understanding of science and thus in need of being educated or disciplined. Or it is suspected of being manipulated by lobbies or in foreign hostile powers, or of being too attached to its own privileges and unwilling to act in favor of the common good. Whose agency is being acknowledged in sociotechnical controversies and whose agency is being denied and why? The seminar will provide a deep understanding of these perspectives, by putting them in a broader historical and epistemological context. Students will thus learn to critically assess their strengths as well as their blind spots.

- **Whereas opposing technological developments (anti 5G or anti-vaccine activists) or pushing to act accordingly to science (pro climate movements such as Extinction Rebellion or Scientist Rebellion), activists’ movements make up for a rich field of investigation on the dynamics of expertise and of how various publics can make sense of scientific knowledge. Cross-fertilizing activist’s texts and experiences with literature in science and technology studies and anthropology, this class will be organized as a structured conversation and a collective mapping of actors and key concepts of sociotechnical controversies. Over the course of the semester, students will learn not only to navigate some of the most heated contemporary debates, but also to articulate their own position on an issue of their choice.**

851-0454-00L

**AI Personhood, Social Justice, and Cross-Cultural Dialogues in the Digital Age**

- **Objective**: The course fosters critical, culturally conscious reflection on AI development and regulation by 1) exploring cross-cultural assessment of the concept of personhood and collective in digital society and how these concepts are reflected in AI development and regulation. 2) Inspring reflection on social justice issues stemming from major (mis)conceptions of personhood in AI development and governance

- **Competencies**
  - Subject-specific Competencies
    - Concepts and Theories
  - Method-specific Competencies
    - Analytical Competencies
  - Social Competencies
    - Communication
  - Personal Competencies
    - Adaptable and Flexible
    - Critical Thinking
    - Self-awareness and Self-reflection

- **Abstract**: The course fosters critical, culturally conscious reflection on AI development and regulation by 1) exploring cross-cultural assessment of the concept of personhood and collective in digital society and how these concepts are reflected in AI development and regulation. 2) Inspring reflection on social justice issues stemming from major (mis)conceptions of personhood in AI development and governance

- **Content**: This course introduces students to the various forms and functions of knowledge and science in literature, particularly within the realm of science fiction, the genre that most directly epitomizes this fundamental connection within literary texts. In analysing how it shifts our understanding of ourselves and of supposedly inalterable facts about the reality we inhabit, we will examine how science fiction demonstrates that fiction is neither fundamentally in conflict with scientific knowledge, as previously supposed, nor a mere vehicle for its celebration, as still commonly presumed of science fiction. Instead, the genre, with its radical investigations into other forms of being, fearing and hoping, plays a crucial role in the social formation, order and negotiation of knowledge. As such, science fiction also represents a vital thought experiment regarding the “science of fiction”, i.e. the development of a knowledge of literature and the many fascinating ways in which it helps us to know our own world better, in turn.

- **In this course, we will take a systematic and theory-based approach to a deeper understanding of science fiction, particularly concerning its historical background, unique aesthetic/narrative tools, and relationship with the critical and technocultural contexts that shape it. Employing contemporary theoretical approaches, we will discuss a variety of themes within primary texts alongside diverse critical sources, all of which ultimately relate to knowledge and knowability. Particular areas of focus may include: other worlds and alien existences; altered temporality and alternate history; utopias and dystopias; climate fiction and the Anthropocene; posthumanist and cyborg identities; robots and AI; and alternative futurisms. Moreover, the course will thereby also engage with the fundamental (and at times overlooked) role of order and presentation of knowledge, i.e. its aesthetic and narrative forms, within science and literature.**
Content

On 13 March 2024, the European Parliament voted in favour of the long-awaited EU AI Act. On October 30, 2023, the US passed an Executive Order on the safe, secure, and trustworthy development and use of AI. Meanwhile, China has been adopting regulations: the 2021 regulation on recommendation algorithms, 2022 rules for deep synthesis (synthetically generated content), and draft rules on generative AI on August 15, 2023. In the face of this race to develop and regulate AI across various legal, regulatory, and cultural settings, this course exposes students to the overarching question: How can we envision an AI-human future that accommodates a pluriverse and ensures a just future?

In everyday life, from education, policy deliberation, planning and prediction, governance of the human behavior and the beyond human, to social and private life, and entertainments, AI systems and AI-enabled products play a significant role. At the very center of this sociotechnical system is the human, often referred to as the ‘data subject’. This raises foundational questions: Who or what is this ‘data subject’? What warrants its protection or what makes it worthy of protection – is it the human dignity, autonomy, rationality, legally protected rights or something beyond and within all these? Who/what is considered a protected ‘data subject’, and who/what is not? While these questions might seem new, they revisit old ethical dilemmas.

However, there is no one-fits-all answer to these questions. Responses vary greatly depending on local and cultural contexts across different jurisdictions and societies. The way AI development and regulatory practices conceptualize the subject of protection – that is, the human and its environment – diverges, leading to varied interpretations of personhood and what warrants protection. What personhood means and what is protected and not are not only matters of policy or legislative interpretations and standardization but a matter of social justice.

With this consideration, the course invites and encourages students to explore the concept of personhood from a cross-cultural perspective, incorporating epistemologies from the ‘South’, including Afro-communitarianism, pluriverse theories, and Confucianism. Students are then guided to critically examine personhood and community within the context of competing AI regulatory frameworks, such as those in the EU, China, Brazil, and the US, as well as in their own interactions with AI systems. By identifying conceptual limitations in current understandings of personhood and the centrality of the collective within contemporary AI regulation and practice, students can address core social justice issues. These include the overemphasis on individualism, which overlooks the communal and relational aspects of existence (including human and the beyond human), the instrumentalization of the environment, and exploitative business models.

Competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Method-specific Competencies
  - Analytical Competencies
  - Social Competencies
  - Communication
  - Personal Competencies
  - Adaptability and Flexibility

862-0123-00L  Benjamin: Experience, History, Architecture

- Abstract
  - This seminar deals with writings by Walter Benjamin. On the one hand, his most famous and influential essays and fragments on critique, history and experience will be read and discussed, and on the other, a special focus will be placed on his thinking on architectural themes.

- Objective
  - On the one hand, students learn to know Walter Benjamin’s most influential ideas, such as his views on art criticism, history and culture, as well as to reflect on his philosophical methods, such as thinking in constellations and pictures. On the other hand, students learn to apply Benjamin’s methods of interpretation (Deutung) to architectural works and the Benjaminian texts themselves.

851-0540-00L  Of Stainless Steel and Biocompatible Ink. History of Materials Science.

- Abstract
  - The seminar examines the history of materials science. Why and how were materials characterized, developed and tested? How did things as diverse as wood, concrete, ceramics and polymers become objects of a single discipline? How did social imaginaries and technical conditions affect scientific work with and on materials?

- Objective
  - Students learn to critically read and interpret different types of texts. They will be familiarised with the interdependencies of technical, scientific and social change. They reflect on (material) scientific practices.

- Content
  - The seminar discusses the socio-technical conditions and effects of materials research from a historical perspective in the 20th century. We observe physicists, chemists and engineers, as well as concrete, foams and electron microscopes, in research laboratories and materials testing institutes, in articles and patents.

851-0040-00L  Can it Be Permissible to Kill a Few in Order to Save Many?

- Abstract
  - First, the relevant literature on moral justifications in trolley cases will be discussed (Foot, Thomson, Kamm, Otsuka, Kagan). Second, neuropsychological research on trolley cases (Greene, Haidt, Berkjer, Kamm) and third, applications of such moral reasoning in cases potentially arising in autonomous robots (Rahwan, Nyholm and Smids, Wolkenstein) will be considered.

- Objective
  - Students will gain an overview of the current ethical debates surrounding the legitimacy of homicide-rescue-cases in specific types of situations. They will be enabled to interpret complex texts, identify the argumentation, to reflect it critically and to put it up for discussion.
Killing innocents is generally thought to be morally impermissible — or so it seems from an intuitive point of view. However, there are situations where people can only be saved if less others are killed, for example in some traffic cases, in some cases in natural disasters, medical emergencies, terrorist attacks or humanitarian interventions. In some of these situations our intuitions stay clear and disapproving: it is not permissible to kill, even in order to save many lives, for example, to take the vital organs of one patient in order to save many more other patients. In other scenarios, the intuitions are less clear or even revert for most of us, like in the famous trolley-bystander case, in which a bystander can divert an out-of-control trolley heading towards five to a track where one person is trapped. How are these moral intuitions to be justified, if they are? In this seminar the relevant literature on moral justifications in such trolley cases will be reviewed as well as on methodological problems pertaining to the role of intuitions in moral justifications. Neuropsychological research on such cases as well as critique of the methods and normative presuppositions used in that research will be debated. Finally, attempts to apply such moral reasoning on allegedly analogous cases arising in autonomous robots will be discussed.

862-0124-00L
Friedrich Nietzsche: Life and Work
W 3 credits 2S A.-A. E. Särkelä

Objective
In our reading group we focus on an in-depth examination of Friedrich Nietzsche's philosophy. By jointly selecting and analyzing his works, we particularly focus on central themes such as morality, power and criticism of science. Our goal is to develop and discuss Nietzsche's philosophical approaches in collective discussions. We strive to jointly reflect and critically question the influence of his ideas on modern culture and science. This cooperative approach not only promotes the understanding of Nietzsche's work, but also the creative development and deepening of one's own thoughts and interpretations within the group.

Semester Report

Number Title Type ECTS Hours Lecturers
862-0006-00L Semester Report O 3 credits 3A Lecturers

Semester Paper

Number Title Type ECTS Hours Lecturers
862-0008-32L Term Paper History of Technology (HS 2024) W 5 credits 11A Lecturers

Semester Report

Number Title Type ECTS Hours Lecturers
862-0006-00L Semester Report O 3 credits 3A Lecturers
Lecturers

Ph.D. students, post docs, members of staff, and senior colleagues from other philosophy departments will report on their work in progress. One-to-one supervisions form the basis for an essay covering the paradigmatic texts studied over several semesters. The instructor will work one-to-one with the student to hone the skills and fundamental topics that are relevant for the Master's thesis.

Number: 862-0021-00L
Title: Essay on Readings in History of Technology (HS) □
ECTS: 2 credits
Hours: 10
Lecturers: Lecturers

Abstract: This essay is the outcome of an individual teaching and learning process during several terms and draws upon representative books and articles in history of technology. It has to consider the state of the art in the field.

Objective: Writing this essays intends to become acquainted with methods, tools and concepts relevant for the students master thesis.

Number: 862-0023-00L
Title: Essay on Readings in Science Research (HS) □
ECTS: 2 credits
Hours: 10
Lecturers: Lecturers

Abstract: This essay is the outcome of an individual teaching and learning process during several terms and draws upon representative books and articles in history of technology. It has to consider the state of the art in the field.

Objective: Writing this essays intends to become acquainted with methods, tools and concepts relevant for the students master thesis.

Number: 862-0025-00L
Title: Essay on Readings in Theoretical Philosophy (HS) □
ECTS: 2 credits
Hours: 10
Lecturers: Lecturers

Abstract: This essay is the outcome of an individual teaching and learning process during several terms and draws upon representative books and articles in history of technology. It has to consider the state of the art in the field.

Objective: Writing this essays intends to become acquainted with methods, tools and concepts relevant for the students master thesis.

Number: 862-0027-00L
Title: Essay on Readings in Practical Philosophy (HS) □
ECTS: 2 credits
Hours: 10
Lecturers: Lecturers

Abstract: This essay is the outcome of an individual teaching and learning process during several terms and draws upon representative books and articles in history of technology. It has to consider the state of the art in the field.

Objective: Writing this essays intends to become acquainted with methods, tools and concepts relevant for the students master thesis.

Number: 862-0029-00L
Title: Essay on Readings in Literature and Culture (HS) □
ECTS: 2 credits
Hours: 10
Lecturers: Lecturers

Abstract: This essay is the outcome of an individual teaching and learning process during several terms and draws upon representative books and articles in history of technology. It has to consider the state of the art in the field.

Objective: Writing this essays intends to become acquainted with methods, tools and concepts relevant for the students master thesis.

Number: 862-0031-00L
Title: Essay on Readings in History of the Modern World (HS) □
ECTS: 2 credits
Hours: 10
Lecturers: Lecturers

Abstract: This essay is the outcome of an individual teaching and learning process during several terms and draws upon representative books and articles in history of technology. It has to consider the state of the art in the field.

Objective: Writing this essays intends to become acquainted with methods, tools and concepts relevant for the students master thesis.

Number: 862-0035-00L
Title: Essay on Readings in History and Philosophie of Mathematical Sciences (HS) □
ECTS: 2 credits
Hours: 10
Lecturers: Lecturers

Abstract: One-to-one supervisions form the basis for an essay covering the paradigmatic texts studied over several semesters.

Objective: The instructor will work one-to-one with the student to hone the skills and fundamental topics that are relevant for the Master's thesis.

Number: 862-0037-00L
Title: Essay on Readings in Ethics, Technology and Society (HS) □
ECTS: 2 credits
Hours: 10
Lecturers: Lecturers

Abstract: One-to-one supervisions form the basis for an essay covering the paradigmatic texts studied over several semesters. This essay should also take recent research into account.

Objective: The instructor will work one-to-one with the student to hone the skills and fundamental topics that are relevant for the Master's thesis.

Seminar

In the seminars topics from the introductory courses are taught in more detail. Topics for essays are to be arranged with the teachers of the courses.

Research Colloquium

In each subject of the master reading lists are handed out. The books on these lists are the subject of the tutorials one has to attend with the teachers that are named in the Leitfaden. In three subjects essays are to be written about works on these lists.

Number: 862-0004-19L
Title: Research Colloquium Philosophy for Master Students and PhD (HS 2024) □
ECTS: 2 credits
Hours: 10
Lecturers: N. Mazouz, R. Wagner

Abstract: Ph.D. students, post docs, members of staff, and senior colleagues from other philosophy departments will report on their work in progress. Furthermore, promising new philosophical articles and parts of new philosophical books will be studied.

Objective: Ideas and arguments dealing with systematic problems especially in epistemology, ethics, political philosophy, and the philosophy of mind will be scrutinized and elaborated.

Number: 862-0078-17L
Title: Research Colloquium. Extra-European History and Global History (HS 2024)
ECTS: 2 credits
Hours: 10
Lecturers: H. Fischer-Tiné, M. Dusinberre

Abstract: PhD students will have an opportunity to improve their presentation skills and obtain an important chance to receive feedback both from peers and more advanced scholars.

Objective: The venue changes each semester alternately between UZH and ETH.

Number: 862-0088-15L
Title: Research Colloquium Science Studies (HS 2024) □
ECTS: 2 credits
Hours: 10
Lecturers: M. Hagner, M. Boenig-Liptsin

Abstract: This colloquium is devoted to the introduction into the theory and practice of scientific work. The schedule can be found on the institute's website: http://www.wiss.ethz.ch/en/teaching/

Objective: This colloquium is devoted to the introduction into the theory and practice of scientific work.

Prerequisites / notice: Lectures may be held either in English or German. Students receive 2 credit points for submitting a brief, written commentary on one of the presented topics (approx. 5 pages).

Number: 862-0089-15L
Title: Advanced Colloquium in Literary Studies (HS 2024) □
ECTS: 2 credits
Hours: 10
Lecturers: A. Kilcher

Abstract: The colloquium addresses advanced and graduate students. First, it offers participants the opportunity to present their own research projects (work in progress); and, second, it provides a most fruitful space to discuss methodological, theoretical and systematic complex issues.

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Objective

The colloquium addresses advanced and graduate students. First, it offers participants the opportunity to present their own research projects (work in progress); and, second, it provides a most fruitful space to discuss methodological, theoretical and systematic complex issues.

Master’s Thesis

The work on the master-thesis is supervised by one of the teachers that are allowed to offer tutorials for it, named in the Leitfaden.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>862-0500-00L</td>
<td>Master’s Thesis ■</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

A student is only permitted to commence the Master thesis if

a. the Bachelor degree programme has been completed
b. any additional requirements for admission to the degree programme have been fulfilled
c. all credits have been acquired in the categories basic courses and major courses and at least 6 credits have been acquired in the category research colloquium

Abstract

The Master’s thesis gives a thorough historical, philological or philosophical analysis of a topic related to the experimental or formal sciences or to technology. It incorporates the relevant research literature on this topic as well as first attempts at original research.

Objective

The master thesis gives a thorough historical, philological or philosophical analysis of a topic related to the experimental or formal sciences or to technology. It incorporates the relevant research literature on this topic as well as first attempts at original research.

History and Philosophy of Knowledge Master - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

<table>
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<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Foundations of Computer Science:

This course provides selected computer science concepts for interdisciplinary projects.

The following topics are covered: introduction to programming, sequence analysis, modeling and simulations, introduction matrices, managing data with relational databases.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-1001-03L</td>
<td>General Chemistry (for HST)</td>
<td>O</td>
<td>6</td>
<td>4V+2U</td>
<td>J. Cvengros</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetics, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.</td>
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<tr>
<td>Objectives</td>
<td>1) Students can explain the importance of evolution for the development of humans and diseases. 2) The students know the cell as the smallest unit of the body. They can explain how the functions of the cell are disturbed in certain diseases and where therapies intervene. They can describe the multiplication of cells in the body and show how errors in this multiplication can lead to diseases. 3) The students know DNA as the basis of life. They can explain how the DNA information is stored and how this information can be reproduced and protected from damage. They can describe how the information is read and translated into proteins. They can explain which mechanisms at the level of DNA, RNA and proteins can cause diseases. 4) Students can explain which technologies can be used to diagnose and treat diseases. 5) Students can explain how people differ genetically and know the molecular basis of these differences. They can explain how these differences can lead to diseases and why some of these differences do not affect diseases. 6) The students know the molecular causes of the most common hereditary diseases and can determine the probability of occurrence and transmission to offspring. 7) Students can explain the biochemical and molecular basis of human reproduction and know the basic principles of human embryonic development. The students can explain which mechanisms can be disturbed by a faulty development.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td></td>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<td></td>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<td></td>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.</td>
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<tr>
<td>252-0852-00L</td>
<td>Foundations of Computer Science</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Dahinden, L. E. Fässler</td>
</tr>
<tr>
<td>Abstract</td>
<td>The students are given an introduction to programming, sequence analysis, modeling and simulations, introduction matrices, managing data with relational databases.</td>
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</tbody>
</table>
### Objective

Students learn to...
- encode a problem into a program, test the program, and correct errors.
- understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- query databases and understand and evaluate the corresponding database model.
- implement models from the natural sciences as a simulation.
- run random experiments and interpret the results.
- explain and apply standard algorithms and evaluate their efficiency.

### Content

1. Variables, data types
2. Control structures, logic
3. Sequential data types, search- and sort algorithms, sequence analysis
4. Functions, modules, simulation and animation
5. Manage data with a relational database
6. Matrices, random experiments, cellular automata

### Literature


This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

### Competencies

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<thead>
<tr>
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<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>Assessed</td>
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<td>Fostered</td>
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<td></td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Problem-solving</td>
<td>Critical Thinking</td>
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<td>Assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>Fostered</td>
<td>Project Management</td>
<td>Self-awareness</td>
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<td>Fostered</td>
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<td>Fostered</td>
<td>and Self-reflection</td>
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<td>Fostered</td>
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<td>Self-direction</td>
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<td>and Self-management</td>
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</tbody>
</table>

### Prerequisites / notice

The course consists of lectures (36 hours) and problem-solving lessons (20 hours, groups of ca. 25 people). In addition, online exercises are available in the e-learning environment Moodle (Course OC I).
Mathematics I

401-0291-00L

6 credits

In Autumn Semester 2024

Abstract
Mathematics I/II is an introduction to one- and multidimensional calculus and linear algebra emphasizing on applications.

Objective
Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences. Students can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems.

Content

### Eindimensionale diskrete Entwicklungen ###
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsrate
- Folgen und Grenzwerte

### Funktionen in einer Variablen ###
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

### Differentialrechnung (I) ###
- Veränderungsrate/-geschwindigkeit
- Differentialquotient und Ableitungsfunktion
- Anwendungen der Ableitungsfunktion

### Integralrechnung (I) ###
- Stammfunktionen
- Integrationstechniken

### Gewöhnliche Differentialgleichungen (I) ###
- Qualitative Beschreibung an Beispielen: Beschränkt, Logistisch, Gompertz
- Stationäre Lösungen
- Lineare DGL 1. Ordnung
- Trennung der Variablen

### Lineare Algebra ###
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

Lecture notes
In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem Vademecum zusammen.

Dabei gilt:

* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

Literature
Siehe auch Lernmaterial > Literatur

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände: Einführung in die Analysis, Einführung in die Lineare Algebra; Haupt-Verlag Bern, UTB.

**H. H. Storrer**

**Ch. Blatter**
Lineare Algebra; VDF und als Skript in der PolyBox

**A. Caspar, N. Hungerbühler**
### Übungen und Prüfungen

+ Die Übungsauflagen (Handaufgaben, Khan-Aufgaben, Multiple-Choice) sind ein wichtiger Bestandteil der Lehrveranstaltung.
+ Es wird erwartet, dass Sie mindestens 9 von 13 der wöchentlichen Serien bearbeiten und zur Korrektur einreichen.
+ Der Prüfungstoff ist eine Auswahl von Themen aus Vorlesung und Übungen. Für eine erfolgreiche Prüfung ist die konzentrierte Bearbeitung der Aufgaben unerlässlich.

### Second and Third Year Core Courses

#### Examination Blocks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0293-00L</td>
<td>Mathematics III</td>
<td>O</td>
<td>5 credits</td>
<td>3V+2U</td>
<td>A. Caspar, N. Hungerbühler</td>
</tr>
</tbody>
</table>

#### Abstract
Vertiefung der mehrdimensionalen Analysis mit Schwerpunkt in der Anwendung der partiellen Differentialgleichungen, Vertiefung der Linearen Algebra und Einführung in die Systemanalyse und Modellbildung.

#### Objective
- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenfalls explizit berechnen: diskret/ kontinuierlich in Zeit, Ebene und Raum.
- können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten.

### Human Physiology I (HS)

• «Kern-Konzepte» in der Physiologie
  1. Struktur und Funktion
  2. Energieübertragung, -speicherung und -nutzung
  3. Informationsfluss, -speicherung und -nutzung
  4. Homöostase
  5. Evolution
• Allgemeine Endokrinologie und endokrines System
• Allgemeine Neurophysiologie und Neuroanatomie
• Die chemischen Sinne, Geschmack und Geruch
• Ernährung und Verdaunung
• Leben und Stoffwechsel
• Energiehomöostase
• Flüssigkeits- und Elektrolytbilanz und Niere
• Reproduktion, Entwicklung und Altern

### Human Physiology II (FS)

• Sinnesphysiologie
• Muskelphysiologie
• Neuronale Kontrolle von Haltung und Bewegung
• Höhere zentralnervöse Hirnfunktionen
• Atmung und Lunge
• Herz und Kreislauf
• Blut
• Immunologie
• Thermoregulation/Fieber
• Stress

### Literature
Wird im Kurs bekannt gegeben.
Einführung Modellbildung

- SIR-Modelle: Ausbreitung von Krankheiten bei Epidemien
- Pocken-Modell: Was ist der Effekt von Impfungen?

Lineare Modelle

- Vektorräume
- Lösungsräume eines linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen

- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle

- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen: Vorgänge, die von Raum und Zeit abhängen

- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Laplace-Transformation

- Definition und Notation
- Rechenregeln
- Anwendungsbeispiele

Lecture notes

Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)

Literature

- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)
- Blatter, C.: Lineare Algebra für Ingenieure, Chemiker und Naturwissenschaftler. ((Siehe später Polybox)

Prerequisites / notice

Vorlesungen Mathematik I/II

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed

Method-specific Competencies
Analytical Competencies
Decision-making
assessed
Problem-solving
assessed

Social Competencies
Cooperation and Teamwork
fostered

Personal Competencies
Creative Thinking
Critical Thinking
assessed

401-0643-13L Statistics II O 3 credits 2V+1U J. Dambon

Abstract
Vertiefung von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptuelle Breite und konkrete Problemlösungsfähigkeit mit der Statistiksoftware R.

Objective

402-0083-00L Physics I O 4 credits 3V+1U K. S. Kirch

Abstract
This course is an introduction to classical physics, with special focus on applications in medicine.

Objective
Obtain an understanding of basic concepts in classical physics and their application (using mathematical pre-knowledge) to the solution of simple problems, including certain applications in medicine.
Obtain an understanding of relevant quantities and of orders of magnitude.

Content
General introduction; Positron-Emission-Tomography as appetizer, including ionising radiation; kinematics of a point mass; dynamics of a point mass (Newton's axioms and forces); physical work, power and energy; conservation of linear and angular momentum; oscillations and waves; mechanics of a rigid body; fluid mechanics; introduction to electricity.

Lecture notes
Will be distributed at the start of the semester.

Literature
"Physik für Mediziner, Biologen, Pharmazeuten", von Alfred Trautwein, Uwe Kreibig, Jürgen Hüttermann; De Gruyter Verlag.

Prerequisites / notice
Voraussetzung Mathematik I-II (Studiengänge Gesundheitswissenschaften und Technologie bzw. Humanmedizin) / Mathematik-Lehrveranstaltungen des Basisjahres (Studiengänge Chemie, Chemieingenieurwissenschaften bzw. Interdisziplinäre Naturwissenschaften)

Competencies
Subject-specific Competencies
Concepts and Theories
assessed

Method-specific Competencies
Analytical Competencies
Problem-solving
assessed

Social Competencies
Communication
fostered

Personal Competencies
Creative Thinking
fostered
### Focus Courses

#### Human Movement Sciences and Sports

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-0203-00L</td>
<td>Movement and Sport Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>W. R. Taylor, R. List</td>
</tr>
</tbody>
</table>

- **Abstract**: Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

- **Objective**: Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics.

- **Content**: Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

- **Competencies**:
  - **Subject-specific Competencies**
    - Concepts and Theories: assessed
    - Techniques and Technologies: fostered
  - **Method-specific Competencies**
    - Analytical Competencies: fostered
    - Problem-solving: fostered
  - **Personal Competencies**
    - Critical Thinking: fostered

- **Literature**: Wird in der Vorlesung bekannt gegeben.

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<tr>
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</thead>
<tbody>
<tr>
<td>376-0207-00L</td>
<td>Exercise Physiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>C. Spengler, F. Gabe Beltrami</td>
</tr>
</tbody>
</table>

- **Abstract**: This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interactions of the different systems influencing factors, e.g. genetics, gender, age, altitude/depth, heat/cold, with respect to performance and health.

- **Objective**: The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/depth, heat and cold on the named factors.

- **Content**: History of Exercise Physiology, research methods, fibertype heterogeneity and its functional significance, neural control of muscle force, molecular and cellular mechanisms of muscle adaptation to resistance, endurance and stretching exercise, interindividual variability in the response to training, cardiorespiratory and metabolic responses to acute and chronic exercise, sex differences relevant to exercise performance, exercise in hot and cold environment, children and adolescents, in sport and exercise, exercise at altitude and depth, aging and exercise performance, exercise for health, exercise in the context of disease.

- **Lecture notes**: Online material is provided during the course.
This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenar discussions.

The course will cover the following topics:

- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prosthesis, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Paraports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention
- Focus-Project Human Movement Science and Sport

Develop and realize a project from A-Z in a team! Applying and deepening existing knowledge, working in teams and independently, learning to structure problems, identifying solutions, system analysis and simulations, as well as presentation and documentation techniques.

- Synthesizing and deepening the theoretical knowledge from the basic courses of semesters 1-4
- Team organization, working in teams, improvement of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problems definitions, searching for information
- System description and simulation
- Presentation techniques, creating documentation
- Decision-making ability, implementation skills
- Expanding and recess of special knowledge

In teams of 3-8 students, the students are integrated into a research group at D-HEST, where they work independently on a project.

Prerequisites / notice
a. First year examinations successfully passed
b. Blocks A, B and C successfully passed by project start

### Medical Technology

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

Introduction into selected topics of biomedical engineering as well as their relationship with physics and psychology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Introduction into selected topics of biomedical engineering as well as their relationship with physics and psychology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.
Content  
History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optical components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.
Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes
Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND
moodle page of the course

Prerequisites / notice
No specific requirements, BUT
HEST and BIOL students will have to learn a lot of new words related to biochemistry, biology and medicine, while

Competencies
Subject-specific Competencies
Concepts and Theories  
Techniques and Technologies  

Method-specific Competencies
Analytical Competencies  
Decision-making  
Media and Digital Technologies  
Problem-solving  

Project Management  

Social Competencies
Communication  
Cooperation and Teamwork  
Customer Orientation  
Leadership and Responsibility  
Self-presentation and Social Influence  
Sensitivity to Diversity  
Negotiation  

Personal Competencies
Adaptability and Flexibility  
Creative Thinking  
Critical Thinking  
Integrity and Work Ethics  
Self-awareness and Self-reflection  
Self-direction and Self-management  

376-0021-00L Materials and Mechanics in Medicine  
W  4 credits  3G  M. Zenobi-Wong, J. G. Snedeker

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective.
Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
Course website on Moodle

Literature
Introduction to Biomedical Engineering, 3rd Edition 2011, 
Autor: John Enderle, Joseph Bronzino, ISBN 9780123749796
Academic Press

376-1714-00L Biocompatible Materials  
W  4 credits  3V  K. Maniura, M. Rottmar, M. Zenobi-Wong

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.
Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.
A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature

(available online via ETH library)

Handouts and references therin.
Rehabilitation and Inclusion

W 3 credits 2G R. Riener

Abstract
This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

Objective
With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenary discussions.

Content
The course will cover the following topics:
- Synthesizing and deepening the theoretical knowledge from the basic courses of semesters 1-4
- Team organization, working in teams, improvement of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problems definitions, searching for information
- System description and simulation
- Presentation techniques, creating documentation
- Decision-making ability, implementation skills
- Expanding and recess of special knowledge

Focus-Project Medical Technology

W 20 credits 43A Professors

Abstract
Develop and realize a project from A-Z in a team! Applying and deepening existing knowledge, working in teams and independently, learning to structure problems, identifying solutions, system analysis and simulations, as well as presentation and documentation techniques.

Objective
- Basic molecular and cell biological mechanisms of cellular ageing; we will also discuss diseases related to cellular ageing and current rejuvenation and therapeutic strategies for cellular ageing in health and disease.
- Diseases related to cellular ageing;
- Current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Content
In teams of 3-8 students, the students are integrated into a research group at D-HEST, where they work independently on a project.

Prerequisites / notice
- a. First year examinations successfully passed
- b. Blocks A, B and C successfully passed by project start

Molecular Health Sciences

Number Title Type ECTS Hours Lecturers
376-1348-00L Cellular Ageing W 3 credits 2V G. Shivashankar

Abstract
Cells undergo major functional alterations as we age. In this course, we will discuss the basic molecular and cell biological mechanisms of cellular ageing. We will also discuss diseases related to cellular ageing and current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Objective
- Basic molecular and cell biological mechanisms of cellular ageing;
- Diseases related to cellular ageing;
- Current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Content
Lecture-1: Hallmarks of cellular ageing
Lecture-2: Cellular microenvironment & extra-cellular matrix
Lecture-3: Cell morphometric changes & cytoskeletal remodeling
Lecture-4: Proteostasis
Lecture-5: Mitochondrial dysfunction
Lecture-6: Endo-membrane signaling
Lecture-7: Nuclear signaling & epigenetic alternations
Lecture-8: Chromatin remodeling & gene expression
Lecture-9: Genomic integrity
Lecture-10: Ageing clock, genome and cellular homeostasis
Lecture-11: Diseases associated with cellular ageing
Lecture-12: Cellular rejuvenation strategies
Lecture-13: Therapeutic interventions to cellular ageing
Lecture-14: Concluding lecture

376-1625-04L Focus-Project Molecular Health Sciences W 20 credits 43A Professors

Autumn Semester 2024
Page 1219 of 2667
Abstract
Develop and realize a project from A-Z in a team! Applying and deepening existing knowledge, working in teams and independently, learning to structure problems, identifying solutions, system analysis and simulations, as well as presentation and documentation techniques.

Objective
- Synthesizing and deepening the theoretical knowledge from the basic courses of semesters 1-4
- Team organization, working in teams, improvement of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problems definitions, searching for information
- System description and simulation
- Presentation techniques, creating documentation
- Decision-making ability, implementation skills
- Expanding and recess of special knowledge

Content
In teams of 3-8 students, the students are integrated into a research group at D-HEST, where they work independently on a project.

Prerequisites / notice
In teams of 3-8 students, the students are integrated into a research group at D-HEST, where they work independently on a project.  

551-0309-00L Concepts in Modern Genetics  
W 6 credits 4V Y. Barral, A. Hajnal, O. Voinnet, University lecturers

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Self-presentation and Social Influence fostered

551-0317-00L Immunology I  
W 3 credits 2V M. Kopf, A. Oxenius

Abstract
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Objective
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung“. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered
Project Management fostered
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Self-direction and Self-management fostered
On successful completion of the module the student should be able to:

1. **Anatomy:** How is the central nervous system structured?

2. **Motor control:** which structures are involved in voluntary and involuntary movements?

3. **Sensory, somatosensory and sensorimotor integration:** how is information from different systems integrated and interpreted by the brain?

4. **Higher brain functions:** What specializations enable us to speak and process emotions and feelings?

**Prerequisites / notice**

Während der Grundvorlesung (Anatomie und Physiologie 1) haben Sie bereits viele der in dieser Vorlesung behandelten Themen kennengelernt, allerdings nicht so detailliert. In dieser Vorlesung wird der Stoff der Grundvorlesung vertieft und erweitert. Es wird vorausgesetzt, dass Sie die in der Grundvorlesung besprochenen Inhalte bereits kennen. Der Stoff aus der Grundvorlesung wird nur teilweise repetiert.

Die Lektionen zur Neurophysiologie enthalten Einheiten des Selbststudiums. Dabei bearbeiten Sie Arbeitsaufträge in einem Polybook, um ein konzeptuelles Verständnis für die behandelten Themen zu entwickeln.

**Abstract**

Advanced knowledge of anatomy and physiology of the nervous system.

**Objective**

The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

**Content**

On successful completion of the module the student should be able to:

- relate structure and function of the nervous system to its development
- apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

**Key skills**

On successful completion of the module the student should be able to:

- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular, and developmental biology to the developing nervous system.

**Lecture notes**

Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

**Literature**

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

**Prerequisites / notice**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO344

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html
Information for UZH students:
Enrolment to this course unit only possible at ETH. Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students-special-students-university-of-zurich.html

Abstract
The course covers the physiology of nerve cells, from the single cell through the neuronal network to the systemic level. The focus is on molecular and cellular mechanisms – synaptic transmission, signal transduction, gene expression, synaptic plasticity.

Objective
Based on an understanding of molecular and cellular mechanisms, the aim is to provide a deepened insight into neurophysiological processes underlying complex brain functions – learning/memory, sleep, sensory.

Content
First, basic molecular and cellular mechanisms in nerve cells (excitability, neurotransmission, signal transduction, gene expression, synaptic plasticity) are introduced. Afterwards, their significance for selected neurophysiological processes (learning/memory, sleep, sensory) will be illuminated.

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle.

Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed

376-1625-01L Focus-Project Neurosciences W 20 credits 43A Professors

Abstract
Develop and realize a project from A-Z in a team! Applying and deepening existing knowledge, working in teams and independently, learning to structure problems, identifying solutions, system analysis and simulations, as well as presentation and documentation techniques.

Objective
- Synthesizing and deepening the theoretical knowledge from the basic courses of semesters 1-4
- Team organization, working in teams, improvement of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problems definitions, searching for information
- System description and simulation
- Presentation techniques, creating documentation
- Decision-making ability, implementation skills
- Expanding and recess of special knowledge

Content
In teams of 3-8 students, the students are integrated into a research group at D-HEST, where they work independently on a project.

Prerequisites
- Prerequisites for the focus projects:
  a. First year examinations successfully passed
  b. Blocks A, B and C successfully passed by project start

551-0309-00L Concepts in Modern Genetics W 6 credits 4V Y. Barral, A. Hajnal, O. Voinnet, University lecturers

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
  - Analytical Competencies: assessed
  - Problem-solving: assessed

- Method-specific Competencies
  - Communication: fostered
  - Cooperation and Teamwork: fostered
  - Self-presentation and Social Influence: fostered

- Social Competencies
  - Creative Thinking: fostered
  - Critical Thinking: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

Bachelor Studies (Programme Regulations 2017)
Second Year Compulsory Courses
Examination Blocks
Examination Block 2

Number Title Type ECTS Hours Lecturers
376-0151-00L Human Physiology I O 5 credits 4V W. Langhans, M. Willecke, to be announced

Abstract
Dieser Kurs vermittelt die Grundlagen der Physiologie und Anatomie des menschlichen Körpers

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Objective

Content
Humanphysiologie I (HS)
- «Kern-Konzepte» in der Physiologie
  1. Struktur und Funktion
  2. Energietransfer, -speicherung und -nutzung
  3. Informationsfluss, -speicherung und -nutzung
  4. Homöostase
  5. Evolution
- Allgemeine Endokrinologie und endokrines System
- Allgemeine Neurophysiologie und Neuroanatomie
- Die chemischen Sinne, Geschmack und Geruch
- Ernährung und Verdauung
- Leber und Stoffwechsel
- Energiehomöostase
- Flüssigkeits- und Nierenhomöostase
- Reproduktion, Entwicklung und Altern

Humanphysiologie II (FS)
- Sinnesphysiologie
- Muskelphysiologie
- Neurionale Kontrolle von Haltung und Bewegung
- Höhere zentralnervöse Hirnfunktionen
- Atmung und Lunge
- Herz und Kreislauf
- Blut
- Immunologie
- Thermoregulation/Fieber
- Stress

Lecture notes
Online-Material wird im Laufe des Kurses zur Verfügung gestellt.

Literature
Wird im Kurs bekannt gegeben.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies fostered

Abstraction
Vertiefung der mehrdimensionalen Analysis mit Schwerpunkt in der Anwendung der partiellen Differentialgleichungen, Vertiefung der Linearen Algebra und Einführung in die Systemanalyse und Modellbildung.

Objective
Die Studierenden
- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenfalls explizit berechnen: diskret/kontinuierlich in Zeit, Ebene und Raum.
- können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten.
Einführung Modellbildung

- SIR-Modelle: Ausbreitung von Krankheiten bei Epidemien
- Pocken-Modell: Was ist der Effekt von Impfungen?

Lineare Modelle

- Vektorräume
- Lösungsraum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen

- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle

- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen: Vorgänge, die von Raum und Zeit abhängen

- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Laplace-Transformation

- Definition und Notation
- Rechenregeln
- Anwendungsbeispiele

Lecture notes

Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)

Literature

- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)
- Blatter, C.: Lineare Algebra für Ingenieure, Chemiker und Naturwissenschaftler. ((Siehe später Polybox)

Prerequisites / notice

Vorlesungen Mathematik I/II

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies

Cooperation and Teamwork fostered

Personal Competencies

Creative Thinking assessed
Critical Thinking assessed

401-0643-13L Statistics II O 3 credits 2V+1U J. Dambon

Abstract

Vertiefung von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

Objective


402-0083-00L Physics I O 4 credits 3V+1U K. S. Kirch

Abstract

This course is an introduction to classical physics, with special focus on applications in medicine.

Objective

Obtain an understanding of basic concepts in classical physics and their application (using mathematical pre-knowledge) to the solution of simple problems, including certain applications in medicine.

Content

General introduction; Positron-Emission-Tomography as appetizer, including ionising radiation; kinematics of a point mass; dynamics of a point mass (Newton's axioms and forces); physical work, power and energy; conservation of linear and angular momentum; oscillations and waves; mechanics of a rigid body; fluid mechanics; introduction to electricity.

Lecture notes

Will be distributed at the start of the semester.

Literature

"Physik für Mediziner, Biologen, Pharmazeuten", von Alfred Trautwein, Uwe Kreibig, Jürgen Hüttermann; De Gruyter Verlag.

Prerequisites / notice

Voraussetzung Mathematik I-II (Studiengänge Gesundheitswissenschaften und Technologie bzw. Humanmedizin) / Mathematik- Lehrveranstaltungen des Basisjahres (Studiengänge Chemie, Chemieingenieurwissenschaften bzw. Interdisziplinäre Naturwissenschaften)

Focus Courses

Human Movement Science and Sport

Number Title Type ECTS Hours Lecturers

Autumn Semester 2024
Learning to view the human body as a (bio-)mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

**Objective**

Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics.

**Content**

Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

**Lecture notes**

Is available within the Moodle

**Competencies**

Subject-specific Competencies | Concepts and Theories | assessed
--- | --- | ---
Techniques and Technologies | fostered

Method-specific Competencies | Analytical Competencies | fostered
--- | --- | ---
Problem-solving | fostered

Personal Competencies | Critical Thinking | fostered
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**Prerequisites / notice**

Enrolment to module BIO348 at UZH. Enrolment to this course unit only possible at ETH. No information for UZH students.

**Literature**

Wird in der Vorlesung bekannt gegeben.

**Number** 551-0309-00L

**Title** Concepts in Modern Genetics

**Type** W

**ECTS** 6 credits

**Hours** 4V

Y. Barral, A. Hajnal, O. Voinnet, University lecturers
Abstract

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective

This course focuses on the concepts of classical and modern genetics and genomics.

Content

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes

Scripts and additional material will be provided during the semester.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Social Competencies

- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence

Personal Competencies

- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

551-0317-00L Immunology I

Abstract

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Objective

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Content

- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Literature

- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice

For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

376-1348-00L Cellular Ageing

Abstract

Cells undergo major functional alterations as we age. In this course, we will discuss the basic molecular and cell biological mechanisms of cellular ageing. We will also discuss diseases related to cellular ageing and current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Objective

- Basic molecular and cell biological mechanisms of cellular ageing;
- Diseases related to cellular ageing;
- current rejuvenation and therapeutic strategies for cellular ageing in health and disease.
### Lecture-1: Hallmarks of cellular ageing
- Cellular microenvironment & extra-cellular matrix
- Cell morphometric changes & cytoskeletal remodeling
- Proteostasis
- Mitochondrial dysfunction
- Endo-membrane signaling
- Nuclear signaling & epigenetic alternations
- Chromatin remodeling & gene expression
- Genomic integrity
- Ageing cell secretome and cellular homeostasis
- Diseases associated with cellular ageing
- Cellular rejuvenation strategies
- Therapeutic interventions to cellular ageing
- Concluding lecture

### Medical Technology

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<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>J. Vöröss, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
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</table>

**Abstract**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orientating the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**
- History of BME and the role of biomedical engineers.
- Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.

**Lecture notes**
- Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino
- moodle page of the course

**Prerequisites / notice**
No specific requirements, BUT
- ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

**Competencies**

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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Critical Thinking</td>
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<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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**Abstract**
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Objective**
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Content**
- Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

**Lecture notes**
course website on Moodle

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The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes

Handouts are deposited online (moodle).

Literature


Handouts and references therein.

376-1220-00L Rehabilitation and Inclusion

Abstract

This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

Objective

With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-facetted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenar discussions.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies

Communication fostered
Cooperation and Teamwork fostered
Leadership and Responsibility fostered
Sensitivity to Diversity fostered

Personal Competencies

Adaptability and Flexibility fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

376-0007-01L Advanced Neuroanatomy and Neurophysiology

Study Regulations 2017: Not useful for students who have already taken the course "Neuroanatomy and Neurophysiology" in the 3rd semester.

Abstract

Advanced knowledge of anatomy and physiology of the nervous system.

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<tr>
<td>376-0007-01L</td>
<td>Advanced Neuroanatomy and Neurophysiology</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>M. Willecke, S. Meissner, D. P. Wolfer</td>
</tr>
</tbody>
</table>

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1228 of 2667
Objective

The course equips students with advanced knowledge of the anatomical structure and function of the most important structures of the central nervous system. They will understand pathophysiological mechanisms and identify explanations for the occurrence of specific symptoms in neurological diseases. They will also be able to apply their knowledge to describe the mechanism of action of drugs. In addition, they will learn the most important methods for analyzing the functions of the nervous system and will be able to use this knowledge to evaluate experimental data.

Content

1. Anatomy: How is the central nervous system structured?

2. Motor control: which structures are involved in voluntary and involuntary movements?

3. Sensory, somatosensory and sensorimotor integration: how is information from different systems integrated and interpreted by the brain?

4. Higher brain functions: What specializations enable us to speak and process emotions and feelings?

Prerequisites / notice


Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

376-1305-00L Development of the Nervous System (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO344

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

Objective

On successful completion of the module the student should be able to

- identify key steps in development underlying neurological syndromes and diseases

Key skills

On successful completion of the module the student should be able to

- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content

The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes

Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz as BIO344

Literature

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice

BIO142 Developmental Biology, BIO143 Neurobiology

376-1305-01L Molecular Neurophysiology: From Molecules to Systems

Information for UZH students: Enrolment to this course unit only possible at ETH. Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

Abstract

The course covers the physiology of nerve cells, from the single cell through the neuronal network to the systemic level. The focus is on molecular and cellular mechanisms – synaptic transmission, signal transduction, gene expression, synaptic plasticity.
Objective

Based on an understanding of molecular and cellular mechanisms, the aim is to provide a deepened insight into neurophysiological processes underlying complex brain functions – learning/memory, sleep, sensory.

Content

First, basic molecular and cellular mechanisms in nerve cells (excitability, neurotransmission, signal transduction, gene expression, synaptic plasticity) are introduced. Afterwards, their significance for selected neurophysiological processes (learning/memory, sleep, sensory) will be illuminated.

Literature

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Analytical Competencies</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
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</table>

551-0309-00L Concepts in Modern Genetics

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

Abstract

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective

This course focuses on the concepts of classical and modern genetics and genomics.

Content

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes

Scripts and additional material will be provided during the semester.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Analytical Competencies</th>
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<tr>
<td>Method-specific Competencies</td>
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4 Electives

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0575-01L</td>
<td>Signals and Systems</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>A. Carron</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.</td>
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<td><strong>Content</strong></td>
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<td><strong>Lecture notes</strong></td>
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<td>Lecture notes available on course website.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Control Systems I is helpful but not required.</td>
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<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<td><strong>Objective</strong></td>
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<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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<td><strong>Content</strong></td>
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<td>Main topics of the course include: - Scaling laws at micro/nano scales - Electrostatics - Electromagnetism - Low Reynolds number flows - Observation tools - Materials and fabrication methods - Applications of biomedical microrobots</td>
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<td><strong>Lecture notes</strong></td>
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<td>The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.</td>
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<td>The lecture will be taught in English.</td>
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<tr>
<td>151-0917-00L</td>
<td>Mass Transfer</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Tibbitt, V. Mavrantzas, C.-J. Shih</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.</td>
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<td><strong>Objective</strong></td>
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<td>This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.</td>
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Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html
Content
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature

Prerequisites / notice
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork
Sensitivity to Diversity

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Lecture notes
Lecture notes, problem set with solutions.

227-0045-00L
Signals and Systems I

Abstract

Objective
Introduction to mathematical signal processing and system theory.

Content

Lecture notes
Lecture notes, problem set with solutions.

237-0113-00L
Foundations of Materials Science I

Abstract
The basic physical concepts for the description of materials are taught, partly in self-study, and applied in exercises. Basic atomistic and macroscopic concepts (e.g. phase diagrams, phase transformations, response functions) are introduced through examples. Selected topics are deepened in classroom lectures.

Objective
Students are able to
- name the basic concepts of materials science. (remember, 1)
- describe simple relations between atomic structure and macroscopic properties. (understand, 2)
- calculate basic material-specific quantities. (apply, 3)
- read and interpret phase diagrams, material characteristic (e.g. stress-strain) diagrams and Ashby plots (analyse, 4)

Content
Atomic structure
Crystalline structure and defects
Thermodynamics, phase diagrams and phase transformations
Diffusion
Mechanical and thermal properties of materials

Literature
Main textbook:
William D. Callister, Jr., David G. Rethwisch
Materials Science and Engineering - An Introduction

Alternatives:
Milton Ohring
Engineering Materials Science

James F. Shackelford
Introduction to Materials Science for Engineers

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Social Competencies
Cooperation and Teamwork

Personal Competencies
Creative Thinking

376-0130-00L
Laboratory Course in Exercise Physiology

Abstract
Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.

Objective
Gain hands-on experience in exercise physiology and consolidate knowledge on physiological adaptations to different types and degrees of physical activity and climatic influences. Learn fundamental assessment techniques of the muscular system, the cardio-respiratory system and of whole-body performance, learn scientifically correct data analysis and interpretation of results. Insight into today's Sports Medicine.
Comprehension for development and changes of sports from the ancient world to the present. Description of sports in services of national ideas, from education and health promotion from the middle of the 18th century till this day.

Objective
Understanding for the development and adaptation of sports from the ancient world to present times.

Content

Lecture notes
Ein Skript für die aktuelle Veranstaltung wird abgegeben.

Literature

Prerequisites / notice
Anatomy and physiology classes and lab course in physiology successfully completed (BWS students please contact C. M. Spengler)

Desirable:
Exercise Physiology Lecture (concomitantly or passed; is selection criterion in case of more applications than lab spaces)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Lecture notes</th>
<th>Credit(s)</th>
<th>V</th>
<th>M. Gisler</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1033-00L</td>
<td>History of Sports</td>
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<td>2V</td>
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<td></td>
<td>Comprehension for development and changes of sports from the ancient world to the present. Description of sports in services of national ideas, from education and health promotion from the middle of the 18th century till this day.</td>
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<td>C. Herrmann</td>
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</table>

Objective
Development of pedagogical-psychological competences for the optimisation of future teaching activities.

Content
- Subject area of educational psychology
- Motivating students in physical education
- Building self-efficacy and strengthen the self-concept
- Promoting positive emotions and a positive attitude to anxiety
- Encouraging self-directed learning
- Leading classes and promoting cooperation
- Communicating with students efficiently
- Reflecting your own expectations critically
- Handling gender issues sensitively
- Promoting inclusion / Strengthening social and moral development
- Dealing with difficult students
- Evaluating achievements of students

Lecture notes
Teaching materials for the individual lectures are provided to the students via moodle.

Literature

Prerequisites
- Group dynamics in sport
- Psychological aspects of sport-injury rehabilitation
- Coach-Athlete-Interaction
- Motivation: goal-setting in sports
- Emotions and stress
- Cognitions in sports: mental rehearsal and mental training
- Introduction to sport psychology
- Cognitions in sports: mental rehearsal and mental training
- Emotions and stress
- Motivation: goal-setting in sports
- Career and career transition in elite sport
- Coach-Athlete-Interaction
- Psychological aspects of sport-injury rehabilitation
- Group dynamics in sport

Specific Risks

Objective
The students learn about important and particularly health-relevant public health topics, phenomena and problems and how to deal with corresponding, public health related questions and problems.

Literature

Students are able to describe selected chemicals, biological and molecular processes that occur in cells spontaneously or after physical or assessed

Subject-specific Competencies
R. Bürgi

The lectures set out to:
- Sociology of Sport
- Sport and social change: developments and trends
- From a public health perspective, there are a number of social circumstances that have a high potential for disease and even increased risk of mortality for the affected populations.

These major social health risks include the following:
- unemployment and social decline
- poverty and social deprivation
- loneliness and social isolation
- migration and social discrimination
- Over-indebtedness and social marginalization
- risky behavior and unhealthy social lifestyles

Such living conditions and behaviors have been shown to cause increased health risks, but do not necessarily mean that all those affected have comparatively poor health or low life expectancy.

Potentially affected individuals, however, do fundamentally represent health risk groups, which include the following groups of people:
- (long-term) unemployed, disengaged, welfare recipients, etc.
- those at risk of and affected by poverty, including homeless, low-income, working poor, single parents, etc.
- Lonely or solitary people and the socially disintegrated
- Refugees, immigrants, foreigners, secondos, etc.
- heavily indebted, insolvent people, people affected by wage garnishment, private bankruptcy, etc.
- addicts (incl. drug, alcohol, gambling and work addicts), underweight or overweight and obese, sedentary and physically inactive people, etc.

Willingness to regularly attend and actively participate in the course.

Prerequisites / notice

<table>
<thead>
<tr>
<th>376-1127-00L</th>
<th>Sociology of Sport</th>
<th>W</th>
<th>2 credits</th>
<th>2V</th>
<th>R. Bürgi</th>
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</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.</td>
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<tr>
<td>Objective</td>
<td>The lectures set out to:</td>
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<td>- present the different dimensions, functions and interrelationships of present-day sport</td>
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<td>- provide an introduction to the central theories and models of (sport) sociology</td>
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<td>- show how far sport reflects society and how it changes and becomes more differentiated in the process</td>
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<td>- take current examples to highlight the sociological view of sport.</td>
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<tr>
<td>Content</td>
<td>Sport and social change: developments and trends</td>
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<tr>
<td>Literature</td>
<td>The economy and the media: commercialisation, logic, dependencies</td>
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<td>Social inequalities and distinctions: social impact, health and sport, sport and gender</td>
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<td>Lecture notes</td>
<td>Selected materials for the lecture are available on the Moodle platform.</td>
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<td>Competencies</td>
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<td>Concepts and Theories</td>
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<td>Analytical Competencies</td>
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<td>Social Competencies</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</table>

A detailed program with additional references will be delivered at the beginning of the lecture.

<table>
<thead>
<tr>
<th>376-1581-00L</th>
<th>Cancer: Fundamentals, Origin and Therapy</th>
<th>W</th>
<th>2 credits</th>
<th>2G</th>
<th>H. Nägeli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Students are able to describe selected chemicals, biological and molecular processes that occur in cells spontaneously or after physical or chemical exposure and resulting in a tumor. They are able to list important cancer-inducing agents and explain the respective mechanism of action. They have knowledge of significant risk factors for cancer diseases. They are confronted with the basics of toxicology and they can explain the principle of the most common therapeutic strategies.</td>
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<td>Content</td>
<td>The lecture deals with problems of tumor epidemiology (causes, mortality, incidence). Cancer is delineated as a multi-step process. Classes of chemical compounds that induce cancer are discussed as well as the reactive metabolites that may be built from. Covalent binding to DNA is discussed and different types of mutations resulting thereof. A selection of proto-oncogenes and tumor suppressor genes is presented. Their function will be discussed as well as the changes which are found in these genes in tumor cells, starting from single nucleotide exchanges up to large deletions. The reason for genetic predisposition to cancer will be discussed as well as cancer relevant aspects of cell cycle regulation. The role of tumor microenvironments and phenomena like angiogenesis and metastasis are presented as well as the mechanisms that protect the genome from mutagenic damage. Further subjects address old and new strategies of cancer treatment. Personalised cancer treatment.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts with reproductions of all presented transparencies will be distributed.</td>
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</table>

additional information is given during the lecture

The lecture requires an active participation of the students. All students will participate in individual or group work focussing on specific subject of the lecture. Students will have ample time for preparation during lecture time.

Prerequisites / notice
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy. All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

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<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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| 376-1661-00L Ethics of Life Sciences and Biotechnology | W 3 credits 2V | A. Blasimme, E. Vayena |

Abstract

This course provides a thorough exploration of drug development and involved ethical issues as well as critical analysis of ethical challenges and practical skills to resolve them. It includes elements of drug discovery, preclinical and clinical research ethics, alternative regulatory pathways and ethics of drug pricing and develops a solid grasp of ethical complexity as well as practical skills.
Basics of Exercise Therapy: 2 credits

Students learn the assessments to plan an exercise-therapy-treatment.

This course is tailored to D-HEST students who want to become familiar with pharmaceutical development and its ethical implications. By C. Perret

**Content**

- Principles of biomedical ethics and how they relate pharmaceutical innovation
- Introduction to drug development, with a focus on the Swiss regulatory ecosystem
- Current trends and impediments to effective drug development, including the use of AI in drug discovery
- Translation of medicine and its ethical implications
- Ethical Aspects of pre-clinical research, including animal replacement technologies like organoids and organ chips
- Ethical aspects of clinical research
- Special regulatory pathways: expanded access / compassionate use
- Special regulatory pathways: accelerated approval
- Drug development and public health. emergency use of new drugs
- Drug pricing: introduction to its regulatory and ethical aspects

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<tr>
<td>376-1716-00L</td>
<td>Basics of Exercise Therapy</td>
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<td>376-1717-00L</td>
<td>Applied Basics in Sports and Exercise Therapy</td>
<td>W</td>
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<td>376-1722-00L</td>
<td>Spinal Cord Injury and Exercise</td>
<td>W</td>
<td>2</td>
<td>2V</td>
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</table>

**Objective**

This course is tailored to D-HEST students who want to become familiar with pharmaceutical development and its ethical implications. By the end of this course, students will have developed a comprehensive understanding of the ethical complexities and challenges in drug development. They will be equipped with the knowledge and analytical skills to navigate ethical reasoning and contribute to the responsible advancement of pharmaceutical research. The specific learning objectives of the course are:

- Discuss relevant legal and public policy frameworks in drug development, ensuring an understanding of the broader regulatory context within which policy and regulatory decisions are made.
- Recognize and identify ethical dilemmas inherent to drug development, fostering a heightened awareness of ethical considerations across various stages of the process.
- Identify and discuss ethical issues in drug development in light of recent advances in the field of artificial intelligence.
- Critically analyze ethical challenges within drug development, enabling them to discuss complex issues, evaluate competing ethical perspectives, and form reasoned judgments.
- Understand the ethical theories and principles that underpin drug regulation.
- Evaluate the ethical implications of alternative pathways, such as Accelerated Approval and Compassionate Use, equipping students to assess potential benefits, risks, and societal consequences.
- Assess the ethical dimensions of drug pricing decisions and their impact on equity and accessibility, encouraging thoughtful reflection on the broader societal implications of pricing strategies.

**Content**

- Principles of biomedical ethics and how they relate pharmaceutical innovation
- Introduction to drug development, with a focus on the Swiss regulatory ecosystem
- Current trends and impediments to effective drug development, including the use of AI in drug discovery
- Translation of medicine and its ethical implications
- Ethical Aspects of pre-clinical research, including animal replacement technologies like organoids and organ chips
- Ethical aspects of clinical research
- Special regulatory pathways: expanded access / compassionate use
- Special regulatory pathways: accelerated approval
- Drug development and public health. emergency use of new drugs
- Drug pricing: introduction to its regulatory and ethical aspects

**Literature**

- Schüle / Huber: Grundlagen der Sporttherapie, Deutscher Ärzteverlag, Köln 2012
- Deimel et al.: Neue aktive Wege in Prävention und Rehabilitations, Deutscher Ärzteverlag, Köln 2007

**Prerequisites / notice**

- 376-1715-00L "Introduction to Exercise Therapy" passed.
- Students learn the assessments to plan an exercise-therapy-treatment.
- They are able to use them. They're able to integrate biological and medical basics.
- They are able to prepare a therapy-session
- Grundlagen der Diagnostik, Anamnese, Bewegungsdagnostik, Funktionsdiagnostik
- Sport- und Bewegungstherapeutische Testverfahren
- Motorische Basisdiagnostik
- Diagnostik bewegungsbezogenen Erlebens und Verhaltens
- Biologisch-medicinische Grundlagen
- Biomechanik (v.a. Gelenke), Pathophysiologische Grundlagen, Modelle der Methodik und Didaktik, Lektionsplanung

**Lecture notes**

- wird vor Semesterbeginn elektronisch zur Verfügung gestellt
- open-book-test in the last sessions at 20.12.2017

**Prerequisites**

- 376-1715-00L "Introduction to Exercise Therapy" passed.
- Does not take place this semester.

**Objective**

- Communication skills and methods of psychoregulation applied to the area of Exercise and Sports Therapy.
- The students are able to plan, lead through and evaluate conversations with patients.
- The students are familiar with a specific method of psychoregulation.
- The participants know different aspects of relationship formation (therapist/client) in therapeutic work.
- Communication and conversation: client-centered forms of conversation in theory and practice
- Psychoregulative Methods: Theoretical and practical insight into various psychoregulative methods

**Lecture notes**

- Documents will be distributed two weeks before lecture.
- The courses "Exercise and Sports Therapy 1 and 2" have been completed successfully.
- A minimum of 90% of attendance if used as credits towards CAS SVGS.

**Prerequisites / notice**

- One seminar day in an institution/company specialized in reintegration of clients into the workforce.
- Open book-test in the last sessions at 20.12.2017

**Prerequisites**

- The following issues will be discussed: Epidemiology and etiology of spinal cord injury; complications and consequences of spinal cord injury; trainability/exercise physiology and spinal cord injury; history and organisation of wheelchair sports; elite sport and spinal cord injury.
**Literature**

General literature:

- H.G. Koch, V. Geng
  Querschnittlähmung verständlich erklärt (Band 1 und Band 2)
  Manfred-Sauer-Stiftung und Schweizer Paraplegiker-Vereinigung
  ISBN 978-3-00-069888-0 (Band 1) und 978-3-00-069889-7 (Band 2)

- G.A. Zäch, H. G. Koch
  Paraplegie - ganzheitliche Rehabilitation
  Karger-Verlag, 2006
  ISBN 3-8055-7980-2

- V. Goosey-Tolfrey
  Wheelchair sport: A complete guide for athletes, coaches and teachers
  Human Kinetics, 2010

- Y.C. Vanlandewijck, W.R. Thompson
  The Paralympic Athlete
  Wiley-Blackwell, 2011
  ISBN 978-1-4443-3404-3

- Liz Broad
  Sports Nutrition for Paralympic Athletes, Second Edition
  CRC Press 2019

- Y.C. Vanlandewijck, W.R. Thompson
  Training and Coaching the Paralympic Athlete
  ISBN 978-1-119-04433-8

**Prerequisites / notice**

Voraussetzung: Vorlesung Anatomie/Physiologie besucht!

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**Abstract**

Introduction to Python Programming provides an overview of the basic programming blocks needed to translate a problem, stated in textual form, into an algorithm that solves it. The course provides an introduction to python programming and covers basics but also Bash scripting, version controlling and an introduction to the use of computer infrastructure such as EULER.

**Objective**

- understand and use variables
- work with common Python data types like integers, floats, strings, characters, lists, dictionaries, as well as pandas DataFrames
- use and implement basic flow control, including for loops and conditionals
- write Python code according to standard style guidelines
- use common python packages and set-up of a coding environment
- manipulate and extract data from pandas DataFrames
- interpret and handle simple error messages with the help of online resources
- have a general understanding of the coding workflow and typical code blocks, data and contained types

**Content**

- General Introduction, installation, IDEs, (virtual) environment setup
- Interpreting and handling error messages, debugging, using online documentation
- Data types, data containers and basic mathematical computations
- Branching and looping
- Writing and reading files
- Writing and using functions
- Data manipulation in pandas
- Data visualization (seaborn, matplotlib)
- Version controlling (git) and cluster submissions, simple bash scripts, slurm submission system

**Prerequisites / notice**

Students should bring a laptop

**Introduction to Python Programming**

**Registration only possible for BSc HST students in 5th semester (or further).**

This course is a required prerequisite for the 'Foundations of Data Science' class in the 6th semester.

**Objective**

- understand and use variables
- work with common Python data types like integers, floats, strings, characters, lists, dictionaries, as well as pandas DataFrames
- use and implement basic flow control, including for loops and conditionals
- write Python code according to standard style guidelines
- use common python packages and set-up of a coding environment
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**Content**

- General Introduction, installation, IDEs, (virtual) environment setup
- Interpreting and handling error messages, debugging, using online documentation
- Data types, data containers and basic mathematical computations
- Branching and looping
- Writing and reading files
- Writing and using functions
- Data manipulation in pandas
- Data visualization (seaborn, matplotlib)
- Version controlling (git) and cluster submissions, simple bash scripts, slurm submission system

**Prerequisites / notice**

Students should bring a laptop

**Nucleic Acids and Carbohydrates**

Note for BSc Biology students: Only one of the two

**Registration only possible for BSc Biology students in 5th semester (or further).**

This course is a required prerequisite for the 'Foundations of Data Science' class in the 6th semester.

**Objective**

- understand and use variables
- work with common Python data types like integers, floats, strings, characters, lists, dictionaries, as well as pandas DataFrames
- use and implement basic flow control, including for loops and conditionals
- write Python code according to standard style guidelines
- use common python packages and set-up of a coding environment
- manipulate and extract data from pandas DataFrames
- interpret and handle simple error messages with the help of online resources
- have a general understanding of the coding workflow and typical code blocks, data and contained types

**Content**

- General Introduction, installation, IDEs, (virtual) environment setup
- Interpreting and handling error messages, debugging, using online documentation
- Data types, data containers and basic mathematical computations
- Branching and looping
- Writing and reading files
- Writing and using functions
- Data manipulation in pandas
- Data visualization (seaborn, matplotlib)
- Version controlling (git) and cluster submissions, simple bash scripts, slurm submission system

**Prerequisites / notice**

Students should bring a laptop
535-0230-00L  Medicinal Chemistry I  W  2 credits  2V  J. Hall

Abstract The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

Objective Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

Content Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions

Objective Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

Content Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions

Literature Mainly based on original literature, a detailed list will be distributed during the lecture

Competencies Subject-specific Competencies Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies Analytical Competencies assessed

Problem-solving assessed

Social Competencies Communication assessed

Cooperation and Teamwork assessed

Personal Competencies Self-awareness and Self-reflection assessed

Self-direction and Self-management assessed

535-0521-00L  Pharmacology and Toxicology I  W  3 credits  2V  U. Quitterer, J. Abd Alla

Abstract This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

Objective The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmaceutical, pathophysiological and clinical aspects.

Content Topics include disease-relevant macroscopic, microscopic, pathochemical and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicity, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

Objective The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmaceutical, pathophysiological and clinical aspects.

Content Topics include disease-relevant macroscopic, microscopic, pathochemical and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicity, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

Literature Recommended reading:


The classic textbook in Pharmacology:


Prerequisites / notice Voraussetzungen: Abschluss Grundstudium

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### Competencies

**Subject-specific Competencies**  
- Concepts and Theories  
- Techniques and Technologies

**Method-specific Competencies**  
- Analytical Competencies  
- Decision-making  
- Media and Digital Technologies  
- Problem-solving  
- Project Management

**Social Competencies**  
- Communication  
- Cooperation and Teamwork  
- Customer Orientation  
- Leadership and Responsibility  
- Self-presentation and Social Influence  
- Sensitivity to Diversity  
- Negotiation

**Personal Competencies**  
- Adaptability and Flexibility

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**Gene Technology**  
**W 2 credits 2G**  
J. Scheuermann, N. Grob

**Abstract**  
The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.

**Objective**  
The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.

**Content**

**I) Genomics and transcriptomics**

- **Methods and Techniques:**  
  - Recombinant DNA technology  
  - Next generation sequencing methods, sequencing of genomes  
  - CRISPR technology  
  Application to human biology:  
  - Functional genomics/transcriptomics  
  - Principles of cancer, genetic diseases  
  - Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

**II) Proteomics**

- **Methods and Techniques:**  
  - Protein cloning and expression  
  - The antibody molecule  
  - Measurement and determination of biomolecular interactions  
  - Protein characterization and engineering  
  - Modifications and radioactive labelling  
  Application to human biology:  
  - Protein therapeutics  
  - Proteomic approaches for identification of novel disease-related targets and biomarkers

**III) Drug discovery: Protein-based libraries**

- **Immune repertoire mining**  
- **Display and selection technologies**  
  1. antibody phage display  
  2. other polypeptide display technologies  
  3. small-molecules display: DNA-encoded chemical libraries

**Lecture notes**  
The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

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**Pharmaceutical Immunology I**  
**W 2 credits 2G**  
C. Halin Winter

**Abstract**  
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

**Objective**  
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

**Content**  
Janeway’s Immunobiology, by Kenneth Murphy et al. (9th or 10th Edition; W.W. Norton & Company).

**Literature**  
Janeway’s Immunobiology, by Kenneth Murphy et al. (9th or 10th Edition; W.W. Norton & Company)

**Paperback**

[www.garlandscience.com]

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**Competencies**

**Subject-specific Competencies**  
- Concepts and Theories  
- Techniques and Technologies

**Method-specific Competencies**  
- Analytical Competencies  
- Critical Thinking

**Personal Competencies**  
- Critical Thinking
Subject-specific Competencies

**Introduction** to the basic knowledge necessary for an understanding of the physiology and pathology of hunger, satiation, satiety, and body weight regulation, how this knowledge is generated, and how it helps improve nutritional advice for healthy people as well as nutritional guidelines for patients.

**Objective**

- The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

**Prerequisites / notice**

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**Competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Problem-solving
- Social Competencies: Self-presentation and Social Influence
- Personal Competencies: Creative Thinking, Critical Thinking

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**376-1987-00L**  
**Physiology of Eating**  
This course was offered as 752-6302-00 up to spring semester 2022 and cannot be chosen again by students who have already received credits for the old course.

**Objective**

Introduction to the basic knowledge necessary for an understanding of the physiology and pathology of hunger, satiation, satiety, and body weight regulation, how this knowledge is generated, and how it helps improve nutritional advice for healthy people as well as nutritional guidelines for patients.

**Literature**

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Problem-solving
- Social Competencies: Self-presentation and Social Influence
- Personal Competencies: Creative Thinking, Critical Thinking

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**752-2120-00L**  
**Consumer Behaviour I**  
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

**Objective**

- Students will be able to,
  - explain the decision-making processes underlying the purchasing process
  - describe the factors that have an influence on consumer behavior
  - develop strategies to influence purchasing behavior

**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies, Decision-making
- Social Competencies: Cooperation and Teamwork, Customer Orientation, Sensitivity to Diversity
- Personal Competencies: Critical Thinking

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**752-4005-00L**  
**Food Microbiology I**  
This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

**Objective**

The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms. The focus of this first part of the two part lecture (Food Micro II is offered in the FS) will be on the organisms, but also on the factors which determine spoilage and foodborne disease.
1. History of Food Microbiology
1.1. Short synopsis of foodborne microorganisms
1.2. Spoilage of Foods
1.3. Foodborne Disease
1.4. Food Preservation
1.5. VIP's of Food Microbiology
2. Overview of Microorganisms in Foods
2.1. Origin of foodborne Microorganisms
2.2. Bacteria
2.3. Yeasts
2.4. Molds
3. Microbial Spoilage of Foods
3.1. Intrinsic and Extrinsic Parameters
3.2. Meats, Seafoods, Eggs
3.3. Milk and Milk Products
3.4. Vegetable and Fruit Products
3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
3.6. Drinks and Canned Foods
4. Foodborne Disease
4.1. Significance and Transmission of Foodborne pathogens
4.2. Staphylococcus aureus
4.3. Gram-positive Sporeformers (Bacillus & Clostridium)
4.4. Listeria monocytogenes
4.5. Salmonella, Shigella, Escherichia coli
4.6. Vibrio, Yersinia, Campylobacter
4.7. Brucella, Mycobacterium
4.8. Parasites
4.9. Viruses and Bacteriophages
4.10. Mycotoxins
4.11. Bioactive Amines
4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

752-6001-00L Introduction to Nutritional Science W 3 credits 2V I. Herter-Aeberli, K. Giller, C. Wolfrum
Abstract
This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.
Objective
To introduce the students to the both macro- and micronutrients in relation to food and metabolism.
Content
The course is divided into two parts: Micronutrients and macronutrients. The micronutrient part includes fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. The macronutrient part introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism. The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeorhesis are emphasized.
Lecture notes
There is no script. Powerpoint presentations will be made available.
Literature
Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies fostered
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Self-presentation and Social Influence fostered
Negotiation fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

752-6301-00L Nutrition-Related Physiology W 3 credits 2V F. von Meyenn, E. Gasser
Abstract
Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand.
Objective
Some basic knowledge in physiology is recommended for this course, which revisits important physiological topics, emphasizing their relation to nutrition. The aim is to give the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand. For students with a background in medicine, pharmacy or biology, the course is useful as a review of previously acquired knowledge. Major topics are basic neuroanatomy and neurophysiology; general endocrinology; the physiology of taste and smell; nutrient digestion and absorption; intermediary metabolism and energy homeostasis; and some aspects of cardiovascular physiology and water balance.
Lecture notes
Handouts for each lecture will be uploaded to Moodle every week.
Abstract
The course introduces basic concepts of the interaction between nutrition and exercise performance.

Objective
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

Content
The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

Lecture notes
Lecture slides and required handouts will be available on the ETH website (moodle).

Literature
Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

Prerequisites / notice
General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).
### Educational Science

Please note that the course unit number will change from autumn semester 2024 onwards. This change has no influence on the course units and achievements completed so far and will be recognized for the respective degree.

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<th>Title</th>
<th>Type</th>
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<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern, M. Rau</td>
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<tr>
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<td>This lecture is only apt for students who intend to enrol in the programs &quot;Teaching Diploma&quot; or &quot;Teaching Certificate&quot;. It is about learning in childhood and adolescence.</td>
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<tr>
<td>Abstract</td>
<td>This course looks into scientific theories and also empirical studies on human learning and relates them to the school.</td>
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<tr>
<td>Objective</td>
<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way human process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
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<td>Thematiche Schwerpunkte: Lernen als Verhaltensänderung und als Informationsverarbeitung; Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzenerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W 1/2 D)</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>S. Maurer, P. Caprez, I. Sargenti</td>
</tr>
<tr>
<td></td>
<td>The successful participation in EW1 (&quot;Human Learning&quot;) and EW2 (&quot;Designing Learning Environments for School&quot;) is recommended, but not a mandatory prerequisite.</td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>In this class, students will learn concepts and skills for coping with psychosocial demands of teaching</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.</td>
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</tr>
<tr>
<td>(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).</td>
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<tr>
<td>(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).</td>
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<table>
<thead>
<tr>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>871-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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</tr>
<tr>
<td>Abstract</td>
<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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<tr>
<td>Objective</td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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</tr>
<tr>
<td></td>
<td>- Get information about recent literature on learning and instruction</td>
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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>871-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>- Understanding of research methods used in the empirical human sciences</td>
<td></td>
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<tr>
<td></td>
<td>- Getting to know intelligence tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Understanding findings relevant for education</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Markwalder</td>
</tr>
<tr>
<td></td>
<td>Adresses to students enrolled either in Teaching Diploma (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>This course unit can only be enrolled after successful</td>
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</tbody>
</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1242 of 2667
Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar (ca. 16 h), 2) collaboration with elementary school teacher in a class (ca. 34 h, with approx. 50% spent in the elementary or middle school class and ca. 50% for preparation), and 3) final report (ca. 10 h). Registration implies participation in all 3 parts.

Objective
Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.).

Content
Students learn more about the potential and challenges of pupils. They get to know the early stages of knowledge as well as the development of pre-concepts of students in their subject area. The seminar with a phase of cooperation consists of three phases: In the block seminar, pre-concepts are discussed in their own subject as well as theoretical inputs from developmental and cognitive psychology. During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students’ level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

Prerequisites / notice
https://www.minterlink.ch/student

Subject Didactics and Professional Training

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-8001-00L</td>
<td>Didactics of Health Sciences and Technology I ♦</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>S. Maurer, S. Sinistaj</td>
</tr>
</tbody>
</table>

Abstract
In this course students learn the principles and techniques of teaching singular lessons, based on scientific knowledge about learning. The aim is to plan, realize, evaluate and reflect lessons effectively and efficiently.

Objective
- Students know how to prepare, conduct and reflect a single lesson based on educational requirements.
- Students take the learning goals as a starting point considering previous knowledge as well as the professional environment and the ambitions of the learners.
- Students apply the basic teaching techniques of their subject area in a sensible way and know how to appropriately arrange the phases of learning.
- Students know how to simplify and present complex technical contents of their subject area.

Competencies
- Subject-specific Competencies:
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies:
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
- Social Competencies:
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies:
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Self-awareness and Self-reflection

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-8008-00L</td>
<td>Teaching Internship Including Examination Lessons ♦</td>
<td>O</td>
<td>6 credits</td>
<td>13P</td>
<td>S. Maurer, S. Sinistaj, further lecturers</td>
</tr>
</tbody>
</table>

Abstract
The teaching internship can just be visited if all other courses of TC are completed. Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

Objective
Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-8011-00L</td>
<td>Mentored Work Subject Didactics Health Sciences and ♦</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>S. Maurer, S. Sinistaj, further</td>
</tr>
</tbody>
</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1243 of 2667
Abstract
The mentored paper is designed to bring together the findings from the FD1 and the FD2. By using various teaching techniques and methods a semester plan, which is based on various curricula will be elaborated for a given topic.

Objective
1. The students have planned a curriculum for a semester course.
2. Students reflect on formative and summative ways such a teaching unit to examine and implement parts of it.
3. The students have implemented parts of the semester curriculum.
4. The students deal with the question to what extend teaching techniques, teaching methods but also sequences of self-study must be involved in the planning.

Prerequisites / notice
Didactics of Health Sciences and Technology II (376-8002-00L)

Health Sciences and Technology TC - Key for Type

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

<table>
<thead>
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<th>Type</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-0300-00L</td>
<td>Essentials in Translational Science</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>J. Goldhahn</td>
</tr>
</tbody>
</table>

**Abstract**
Translational science is a cross-disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicines). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

**Objective**
After completing this course, students will be able to understand:
- Principles of translational science including medical device development, intellectual property, regulatory environment and project management
- Students should be able to apply this knowledge in drug development programs in Pharma, Biotech or their own spin-off.

**Content**
- What is translational science and what is it not Including:
  - How to identify need?
  - How to choose the appropriate research type and methodology
  - How to measure success?
  - How are medical devices developed?
  - How to handle IP in the development process?
  - How does the regulatory environment impact innovation?
  - How to manage complex development projects?
- Positive and negative examples will be illustrated by distinguished guest speakers.

**Literature**
Principles of Biomedical Sciences and Industry
Translating Ideas into Treatments
https://doi.org/10.1002/9783527824014

**Prerequisites / notice**
4x online input lecture followed by case preparation and symposium

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories assessed</td>
<td>Analytical Competencies assessed</td>
<td>Communication fostered</td>
<td>Adaptability and Flexibility fostered</td>
</tr>
<tr>
<td>Techniques and Technologies fostered</td>
<td>Decision-making assessed</td>
<td>Cooperation and Teamwork fostered</td>
<td>Critical Thinking assessed</td>
</tr>
<tr>
<td>Problem-solving assessed</td>
<td>Customer Orientation fostered</td>
<td>Negotiation fostered</td>
<td>Integrity and Work Ethics fostered</td>
</tr>
<tr>
<td>Project Management fostered</td>
<td></td>
<td></td>
<td>Self-awareness and Self-reflection fostered</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Self-direction and Self-management fostered</td>
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## Electives

### Electives Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0221-00L</td>
<td>Methods and Concepts in Human Systems</td>
<td>W</td>
<td>4</td>
<td>3P</td>
<td>S. Gerritzen, L. Imbach, D. Ledergerber Wäller, W. Potok-Szybinska</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
Students will get familiar with:
- Key Ethics documents
- (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

**Content**

Module 1:
Research and Research Ethics, Guidelines, (Inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

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Abstract
This course provides hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (nerve/brain stimulation, EMG, EEG, psycho-physical paradigms etc). Students read scientific material, set up experiments, perform measurements in the lab, analyse data, apply statistics and write short reports or essays.

Objective
This course will prepare students for experimental work as it is typically done during the master thesis. The goal is to gain hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (for example peripheral nerve stimulation, electrical and magnetic brain stimulation, EMG, EEG, psycho-physical paradigms etc). Students will learn how to perform small scientific projects in this area. Students will work individually or in small groups and solve scientific problems which require them to perform measurements in human participants, extract relevant readouts from the data, apply appropriate statistics and interpret the results. They will also be required to write small essays and reports and they will get feedback on their writing throughout the course.

Prerequisites / notice
Students are required to have successfully completed the course "Neural control of movement and motor learning" and to have basic knowledge of applied statistics.

376-0223-00L
Advanced Topics in Exercise Physiology
W 4 credits 2S
C. Spengler, G. D'Hulst, F. Gabe Beltrami

Abstract
In this course, students read, present and discuss seminal publications in the area of exercise physiology. The focus lies on critical analysis of scientific content, conceptual as well as ethical aspects of publications. Students are trained in the most common scientific presentation techniques such as oral and poster presentations.

Objective
Students gain further knowledge and a deeper understanding of concepts in exercise physiology. Emphasis is put on critical analysis and discussion of scientific publications as well as on improving scientific presentation skills.

Content
About two third of the semester will be spent discussing structure and content of 2-3 scientific papers per double-lecture. This includes a student presenting the paper orally first, followed by the group discussion. Each student will also prepare and present a poster on a self-selected, scientific publication, participate in a poster discussion session and lead another discussion session as a facilitator. Students groups will prepare a scientific study design to a given, applied exercise physiology question. Furthermore, students will compare an article published in the lay press to the scientific publication the article is based on.

Literature
Material will be provided in moodle.

Prerequisites / notice
Successful completion of the Exercise Physiology Course.

376-0225-00L
Critical Appraisal of Evidence for Exercise in Health
W 3 credits 2V
E. Giannouli, E. de Bruin, R. Knols and Disease

Abstract
This course will discuss the mechanisms and latest evidence-based recommendations of physical activity and exercise for a series of conditions and populations.

In the second part of each lecture session, published randomized controlled trials of the respective lecture’s topic will be discussed and critically appraised based on established tools.

Objective
On completion of this course students will be able to:
1. understand the role of physical activity and sedentary behavior in the maintenance of health and the etiology, prevention and treatment of disease
2. synthesize effective physical activity and exercise interventions for the prevention and management of several diseases and populations
3. evaluate recent evidence regarding physical activity and exercise interventions

Content
New trends in physical activity for prevention and rehabilitation
Introduction to critical appraisal tools
Exercise for Cancer Rehabilitation
Exercise for Musculoskeletal Rehabilitation (Focus on Osteoarthritis and Low Back Pain)
Exercise in Parkinson’s disease
Exercise for Rehabilitation of Metabolic Disorders (Focus on Obesity and Diabetes type 2)
Exercise for age-related diseases and disorders, Part A (Focus on Frailty and Falls)
Exercise for Stroke Rehabilitation
Exercise in Dementia and Mild Cognitive Impairment
Exercises and Experiences (Focus on Cerebral Palsy)
Exercise for age-related diseases and disorders, Part B (Focus on Sarcopenia and Osteoporosis)
Exercise in Multiple Sclerosis
Exercise for Cardiovascular Rehabilitation (Focus on Heart Failure)

Literature

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered
Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered
Critical Thinking assessed
Integrity and Work Ethics fostered

376-1651-00L
Clinical and Movement Biomechanics
W 4 credits 3G
D. K. Ravi, S. H. Hosseini Nasab, R. List, further lecturers

Abstract
Measurement and modeling of the human movement during daily activities and in a clinical environment.

Objective
The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

Content
This course includes study design, measurement techniques, clinical testing, accessing movement data and anaysis as well as modeling with regards to human movement.

752-6101-00L
Nutrition and Chronic Disease
W 3 credits 2V
F. von Meyenn, M. Andersson

Abstract
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Objective
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Content
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Lecture notes
There is no script. Powerpoint presentations will be made available on-line to students.

Literature
To be provided by the individual lecturers, at their discretion.

No compulsory prerequisites, but prior completion of the courses “Introduction to Nutritional Science” and “Advanced Topics in Nutritional Science” is strongly advised.
# Elective Courses II

<table>
<thead>
<tr>
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<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüssmann</td>
</tr>
</tbody>
</table>

## Abstract
Introduction into diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

## Objective
Upon completion of the course students are able to:
- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

## Content
- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PECT)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

## Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

## Prerequisites / notice
Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

## Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technics and Technologies</td>
<td>assessed</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision-making</td>
<td>fostered</td>
<td></td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>fostered</td>
<td></td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

## Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed

## Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-direction and Self-management: fostered

<table>
<thead>
<tr>
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<td>Biomedical Engineering</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
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</table>

## Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

## Objective
In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

## Content
- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.

## Lecture notes
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzingo

AND
moodle page of the course

## Prerequisites / notice
No specific requirements, BUT
- ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while
- HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Competencies

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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### 227-0447-00L Image Analysis and Computer Vision

**W 6 credits 3V+1U E. Konukoglu, E. Erdil, F. Yu**

**Abstract**


**Objective**

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Content**

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches for image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Lecture notes**

Course material, Script, computer demonstrations, exercises and problem solutions

**Prerequisites / notice**

Prerequisites: Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

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### 263-5057-00L From Publication to the Doctor’s Office

**W 3 credits 2S+1A O. Demler**

**Abstract**

This seminar course is designed to provide students with an opportunity to review and critically evaluate recent publications in medical field focusing on examples when CS method or bioinformatics/statistical technique has lead to an instrumentation, technique or drug approved for clinical practice use.

**Objective**

Throughout the course, students will read and analyze recent publications that demonstrate successful applications and sometimes failures in medicine. Promising research applications will also be discussed. The publications will cover a wide range of topics, including drug discovery, image analysis, prognostic models, and learning healthcare.

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Content

The course will be structured as half lecture content and half seminar content. Lectures will review state of the medical practice prior to the discovery, obstacles in moving the field forward, and the need for improvement. Lecture will be followed by the seminar part where students will take turns presenting the assigned publications and leading the discussions. Students’ presentations will focus on the main findings, and specific steps taken to translate the finding into clinical practice.

Publications will include examples of:
- specific CS/bioinformatics/statistics applications that has been brought to „bedside“ – has been approved by European Medicines Agency / Food and Drug Administration (USA) for clinical use or are widely used in medical research;
- examples of failures of how a discovery did not translate into an endproduct and why;
- current active research areas.

Covered topics will include some of the following:
- Drug discovery: Computer-aided drug discovery has become an integral part of the drug development process, enabling researchers to design and screen large libraries of molecules in silico (i.e., using computer simulations) before synthesizing and testing them in the lab. This has led to the discovery of new drug candidates for a wide range of diseases, including cancer, Alzheimer’s disease, and HIV/AIDS.
- Genomics: Advances in computational genomics have enabled researchers to analyze and interpret large-scale genomic data, including DNA sequencing data, to identify disease-causing mutations, genetic risk factors, and drug targets. Examples of the development of personalized medicine, where treatments are tailored to an individual’s genetic makeup. Examples when drug target identified by genetics has led to approved treatment.
- Imaging: Computer vision and image processing techniques have revolutionized medical imaging, enabling researchers to extract quantitative information from medical images that were previously inaccessible. This has led to the development of new diagnostic and prognostic tools for a wide range of diseases, including cancer, cardiovascular disease, and neurological disorders.
- Real-world data applications: emulation of clinical trials using electronic health records data.
- Large language models: Generating clinical trial protocols using large language models. Natural Language Processing for information extraction and interpretation.
- Learning healthcare systems: Advances in data analytics and information technology have enabled the development of learning healthcare systems, which use real-time data from electronic health records, medical devices, and other sources to improve patient outcomes and reduce healthcare costs. This has the potential to transform the way healthcare is delivered, making it more personalized, efficient, and effective.

In addition to the presentations, students will also be required to write critical reviews of the assigned publications throughout the course. The reviews will be evaluated based on the students’ ability to identify the strengths and weaknesses of the publications and to provide insightful and constructive feedback.

Prerequisites / notice

The course is intended for advanced undergraduate and graduate students with a background in computer science, bioinformatics, or a related field and interest in applying their skills to medical research.

This course assumes a working knowledge of R/Python and intermediate statistical analysis, including linear, logistic, survival regressions or ability and interest to learn them outside of the class.

Competencies

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<thead>
<tr>
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<th>Social Competencies</th>
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327-2125-00L Microscopy Training SEM I - Introduction to SEM ■

W 2 credits 3P


For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP.html).

All applicants must additionally register on this form:
https://docs.google.com/forms/d/1Xw8L_2yXTE9qXw6C6mJkMVq9xVxSjEa-9CwDXkd0/edit

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective

- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.
Content During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imagining modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Prerequisites / notice No mandatory prerequisites.

<table>
<thead>
<tr>
<th>Code</th>
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<th>Instructor</th>
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<td>3</td>
<td>2G</td>
<td>G. Grote</td>
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<td>327-2126-00L</td>
<td>Microscopy Training TEM I - Introduction to TEM</td>
<td>2</td>
<td>3P</td>
<td>P. Zeng, E. J. Barthazy Meier, A. G. Bittermann, F. Gramm, A. Sologubenko</td>
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</tbody>
</table>

Objective
Understanding of
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

Content
Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

Practicals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

Prerequisites / notice
No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

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Content

The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterium
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

Literature

A list of required readings will be provided at the beginning of the course.

Prerequisites / notice

The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are founding, financing and growing a venture.

A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Content

Weekly sessions - recorded.
10+ sessions carried out by guest lecturers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...). Final session: multiple choice semester assignment (100% of grade).

Typical lecture format (2h):
15’: Introduction
60’: Guest testimonial
15’: Discussion related to topic (in groups)
10’: Plenary discussion
20’: Q&A with (guest) lecturer

Lecture notes

Lecture slides and case material

Competencies

Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Critical Thinking

Abstract

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

363-0790-00L Technology Entrepreneurship W 2 credits 2V F. Hacklin

363-1163-00L Developing Digital Biomarkers W 3 credits 2V F. Da Conceição Barata
Objective

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world's aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:

• understand the anatomy of digital biomarkers
• understand the potential and applications of digital biomarkers
• be able to critically reflect and assess existing digital biomarkers
• be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as "deep learning") have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

Competencies

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</table>

Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

Abstract

The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

The learning objectives include

1. advanced knowledge of the state-of-the-art in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Objectives

376-0121-00L Multiscale Bone Biomechanics W 6 credits 3S R. Müller, X.-H. Qin

Autumn Semester 2024
Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions courses focused on Quality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A).

Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

### Lecture notes

Material will be provided on Moodle and eColab.

### Comprehibilities

**Subject-specific Competencies**

- **Concepts and Theories**
- **Techniques and Technologies**

**Method-specific Competencies**

- **Analytical Competencies**
- **Decision-making**
- **Media and Digital Technologies**
- **Problem-solving**
- **Project Management**

**Social Competencies**

- **Communication**
- **Cooperation and Teamwork**
- **Self-presentation and Social Influence**
- **Sensitivity to Diversity**

**Personal Competencies**

- **Adaptability and Flexibility**
- **Creative Thinking**
- **Critical Thinking**
- **Integrity and Work Ethics**
- **Self-awareness and Self-reflection**
- **Self-direction and Self-management**

### 376-0130-00L Laboratory Course in Exercise Physiology

**Objective**

Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.

**Content**

Laboratory course:
- Various exercise tests assessing human performance and assessments of physiological responses to activity (examples are VO2max-test, Conconi-Tests, Determination of anaerobic threshold, Cooper-Test, 1-repetition maximum test, lactate minimum test), dynamometry, mechanography, body composition etc.). Insight into measurements in Sports Medicine.

**Lecture notes**

Tutorial on Laboratory Experiments in Exercise Physiology

(Editors: Exercise Physiology Lab)

**Literature**

- Schmidt/Lang/Heckmann: Physiologie des Menschen, Springer-Verlag, Heidelberg
- Kenney/Wilmore/Costill: Physiology of Sport and Exercise, Human Kinetics

**Prerequisites / notice**

Anatomy and physiology classes and lab course in physiology successfully completed (BWS students please contact C. M. Spengler)

Desirable:
- Exercise Physiology Lecture (concomitantly or passed; is selection criterion in case of more applications than lab spaces)

### 376-0203-00L Movement and Sport Biomechanics

**Objective**

Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

**Content**

- Students are able to describe the human body as a mechanical system.
- They analyse and describe human movement according to the laws of mechanics.
- Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

**Lecture notes**

- Is available within the Moodle

**Comprehibilities**

**Subject-specific Competencies**

- **Concepts and Theories**
- **Techniques and Technologies**

**Method-specific Competencies**

- **Analytical Competencies**
- **Problem-solving**

**Personal Competencies**

- **Critical Thinking**
Exercise Physiology W 4 credits 3G C. Spengler, F. Gabe Beltrami

Abstract
This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interactions of the different systems influencing factors, e.g. genetics, gender, age, altitude/depth, heat/cold, with respect to performance and health.

Objective
The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/depth, heat and cold on the named factors.

Content
History of Exercise Physiology, research methods, fibertype heterogeneity and its functional significance, neural control of muscle force, molecular nad cellular mechanisms of muscle adaptation to resistance, endurance and stretching exercise, interindividual variability in the response to training, cardiorespiratory and metabolic responses to acute and chronic exercise, sex differences relevant to exercise performance, exercise in hot and cold environment, children and adolescents. in sport and exercise, exercise at altitude and depth, aging and exercise performance, exercise for health, exercise in the context of disease.

Lecture notes Literature
Online material is provided during the course.

Prerequisites / notice
Wird in der Vorlesung bekannt gegeben.

Molecular and Cellular Biology of Exercise and Muscle Regeneration - Practical Aspects

Prerequisites:
Laboratory Course in Molecular Biology (376-0006-02L)

Abstract
The skeletal muscle biology field purposes to understand how muscles coordinate movement, regenerate following injury and adapt to exercise stimuli. In this course, the students will acquire insights into the molecular aspects of muscle biology and exercise, in addition to gaining hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise.

Objective
The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

Content
The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students- each one will focus on one of the following research topics:

1. Topic 1: Molecular pathways that control muscle stem cell self-renewal and differentiation
2. Topic 2: Genome engineering to correct genetic mutations that cause muscle diseases
3. Topic 3: Muscle fiber composition, force production and insulin sensitivity
4. Topic 4: Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session.

For the journal club, each group of students will receive a peer-review article that is highly relevant to the respective group’s research topic. Each of the 4 groups will present and discuss the article in a journal club format to the rest of the participants the following week. During the four practical sessions, students will gain hands-on experiences and learn different lab techniques related to molecular biology of exercise and muscle regeneration. Each group will be presented with a research objective that is related to their topic, and perform in collaboration with teaching assistants a set of experiments that aim to address the research objective. At the final evaluation session, each group of students will present their results and identify follow-up research questions and hypothesis based on their experimental achievements.

Select practical methods that the proposed course will teach include:

i. Group 1: tissue culture, isolation of muscle stem cells via FACS, differentiation of muscle stem cell into muscle fibers, small molecules screens, quantitative analysis of muscle cell proliferation and fusion, Immunofluorescence.

ii. Group 2: tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crispr-Cas9 gene editing of genetic mutations that cause muscle diseases in muscle stem cells and fibers. Immunofluorescence and PCR.

iii. Group 3: ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, immunofluorescence and western blot.

iv. Group 4: tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers, Western blot.

Prerequisites / notice
Prerequisites: 376-0006-02L Laboratory Course in Molecular biology

Applied Human Research Project Management W 4 credits 3G C. Lustenberger, M. Altermatt

Abstract
This course equips the students with several key principles such as good clinical practice, ethical study requirements, reproducible data management and effective oral, graphical, and written communication to design and manage good quality, ethically sound human research studies and represents a 101-toolkit of transferable research management skills/digital tools.

Objective
The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

• Create/select well-founded research hypotheses and study designs for a specific research topic
• Apply universal good clinical practice guidelines in future research projects
• Integrate well-documented data management and open science principles into future research projects
• Integrate principles of effective communication in speaking, writing and graphical illustrations of future research idea/output

Content
The course will cover the following topics:

• Introduction to different study designs and ethical requirements thereof in Switzerland
• Introduction to literature search and searching platforms
• How to collect and sort publications/ keep up to date on research topic
• Inputs on critically evaluating papers
• How to pre-define study requirements to "future-proof" the research (hypothesis, sample size definition, pre-registration)
• Correct conduction of fundamental human research procedures (e.g., screening, consent process, CRF) and identification/prevention of deviations and emergencies (e.g., SAE/AE, protocol violation, research misconduct)
• Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metatiles)
• FAIR principles and open science
• Design principles and free digital tools for graphical illustrations
• Effective summarizing of research output/topic in an abstract and pitch presentation

History of Sports W 2 credits 2V M. Gisler

Abstract
Comprehension for development and changes of sports from the ancient world to the presence. Description of sports in services of national idea, from education and health promotion from the middle of the 18th century till this day.

Objective
Understanding for the development and adaptation of sports from the ancient world to present times.
### 376-1107-00L Sport Pedagogy

**Abstract**

The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the classical social science / sports pedagogical perspective. Therefore, this lecture will be focused on "pedagogical-psychological aspects of competence development in the context of a multi-perspective physical education".

**Objective**

Development of pedagogical-psychological competences for the optimisation of future teaching activities.

**Content**

- Subject area of educational psychology
- Motivating students in physical education
- Building self-efficacy and strengthen the self-concept
- Promoting positive emotions and a positive attitude to anxiety
- Encouraging self-directed learning
- Leading classes and promoting cooperation
- Communicating with students efficiently
- Reflecting your own expectations critically
- Handling gender issues sensitively
- Promoting inclusion / Strengthening social and moral development
- Dealing with difficult students
- Evaluating achievements of students

**Literature**


### 376-1117-00L Sport Psychology

**Abstract**

This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.

**Objective**

Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to explain the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students' expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.

**Content**

- Main Topics
  - Introduction to sport psychology
  - Cognitions in sports: mental rehearsal and mental training
  - Emotions and stress
  - Motivation: goal-setting in sports
  - Career and career transition in elite sport
  - Coach-Athlete-Interaction
  - Psychological aspects of sport-injury rehabilitation
  - Group dynamics in sport

**Literature**


### 376-1127-00L Sociology of Sport

**Abstract**

These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.

**Objective**

The lectures set out to:
- present the different dimensions, functions and interrelations of present-day sport
- provide an introduction to the central theories and models of (sport) sociology
- show how far sport reflects society and how it changes and becomes more differentiated in the process
- take current examples to highlight the sociological view of sport

**Content**

Sport and social change: developments and trends
- the economy and the media: commercialisation, logic, dependencies
- Social inequalities and distinctions: social impact, health and sport and gender
- Conflicts and politics: sports organizations, doping, violence

**Literature**


**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Sensitivity to Diversity
- Personal Competencies: Critical Thinking

### 376-1176-00L Wearable and Mobile Technologies of the Future - Focus on Sports and Health

**Abstract**

This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the

The course consists of two modules.

Module 1: Movement
This module provides the scientific background needed to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies.

Module 2: Cardiac.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies and the latest data analysis techniques to monitor the cardiac cycle for assisting individuals in sport activities or monitoring their health conditions.

Prerequisites / notice
- Students should be proficient in programming (any language).
- Note: assignments will be in MATLAB. Students are expected to learn MATLAB on their own if not experienced with this programming language.
- Course prerequisites:
  - For Biomedical Engineering Master’s: none
  - For ITET Master’s: none
  - For D-MAVT Master’s: none
  - For D-HEST Master’s and PhD students:
    - If BSc in electrical/mechanical engineering or computer science: none
    - If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)

<table>
<thead>
<tr>
<th>376-1177-00L</th>
<th>Human Factors I</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>M. Menozzi Jäckli, R. Huang</th>
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</thead>
<tbody>
<tr>
<td>Objective 1:</td>
<td>Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.</td>
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<td>Objective 2:</td>
<td>Acquire skills to design novel non-invasive technologies for sport and health.</td>
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<tr>
<td>Content</td>
<td>The course consists of two modules.</td>
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<tr>
<td>Abstract</td>
<td>Strategies of human-system-interaction, individual needs, physical &amp; mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.</td>
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<tr>
<td>Objective</td>
<td>Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.</td>
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<td>Content</td>
<td>- Physiological, physical, and cognitive factors in sensation, perception, and action</td>
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<td></td>
<td>- Body spaces and functional anthropometry, Digital Human Models</td>
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<td>- Experimental techniques in assessing human performance, well-being, and comfort</td>
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<td>- Usability engineering in system designs, product development, and innovation</td>
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<td></td>
<td>- Human information processing and biological cybernetics</td>
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<td>- Interaction among consumers, environments, behavior, and tasks</td>
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<tr>
<td>Literature</td>
<td>- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students</td>
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<td></td>
<td>- Further textbooks are introduced in the lecture</td>
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<td>- Brouchures, checklists, key articles etc. are uploaded in ILIAS</td>
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<tr>
<th>376-1179-00L</th>
<th>Applications of Cybernetics in Ergonomics</th>
<th>W</th>
<th>1 credit</th>
<th>1U</th>
<th>M. Menozzi Jäckli, Y. Hedinger Huang, R. Huang</th>
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<tbody>
<tr>
<td>Objective</td>
<td>Learn and practice cybernetics principles in interface designs and product development.</td>
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<td>Content</td>
<td>- Fitt's law applied in manipulation tasks</td>
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<td></td>
<td>- Hick-Hyman law applied in design of the driver assistance systems - Vigilance applied in quality inspection</td>
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<td>- Accommodation/vergence crosslink function</td>
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<td></td>
<td>- Cross-link models in neurobiology- the ocular motor control system</td>
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<tr>
<th>376-1219-00L</th>
<th>Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>R. Rienner, O. Lambercy</th>
</tr>
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<tbody>
<tr>
<td>Objective</td>
<td>Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.</td>
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<tr>
<td>Objective</td>
<td>This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.</td>
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</table>
Content

Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature

Introductory Books:


Selected Journal Articles and Web Links:

Prerequisites / notice

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Target Group:
- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

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Rehabilitation and Inclusion

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Social Competencies
- Communication: fostered

Personal Competencies
- Leadership and Responsibility: fostered

376-1220-00L Rehabilitation and Inclusion

W 3 credits 2G R. Riener

Abstract
This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

Objective
With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-facetted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenary discussions.

Content
The course will cover the following topics:
- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prosthesis, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Para-sports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention

Nanostructured Materials Safety

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Social Competencies
- Communication: fostered

Personal Competencies
- Leadership and Responsibility: fostered
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

376-1353-00L Nanostructured Materials Safety

W 2 credits 1V P. Wick, T. Bürki-Thurnherr

Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.

Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.

Content
Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily live. These customized nanomaterials provides extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials.

The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications and intravenous injections as well as it will provide impulses for safer material designs.

Structure of the planed lecture (2 x 45 min)
1. Introduction: the principles of nanotoxicology
2. Lung- particles interactions: two disease scenarios and their molecular mechanism
3. GI – particles interactions: intendent and unintendent particle exposure via food
4. Skin – particles interactions: body care products and their influence on skin physiology
5. intravenous injection: colloidal stability, protein corona and cellular effects
6. Micro- / Nanoplastics and development of a safety research plan
7. End of semester exam

Lecture notes
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

Prerequisites / notice
course “Introduction to Toxicology”
This course provides a thorough exploration of drug development and involved ethical issues as well as critical analysis of ethical concepts and theories. The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and innovation and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

Objectives:
- Identify ethical issues in life sciences and biotechnology.
- Analyze and critically discuss ethical issues in life sciences and biotechnology.
- Become aware of relevant legal and public policy frameworks.
- Distinguish different ethical approaches and argumentative strategies in applied ethics.
- Recognize how ethical issues relate to different accounts of technology and innovation.
- Develop a personal and critical attitude towards the ethical aspects of science and technology in the domain of human health.
- Autonomously anticipate ethical issues.
- Propose and communicate solutions to ethical challenges and dilemmas.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Project Management
- Social Competencies
  - Communication
  - Cooperation and Teamwork

376-1661-00L Ethics of Life Sciences and Biotechnology
- W 3 credits
- 2V
- A. Blasimme, E. Vayena

Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

- Identify ethical issues in life sciences and biotechnology.
- Analyze and critically discuss ethical issues in life sciences and biotechnology.
- Become aware of relevant legal and public policy frameworks.
- Distinguish different ethical approaches and argumentative strategies in applied ethics.
- Recognize how ethical issues relate to different accounts of technology and innovation.
- Develop a personal and critical attitude towards the ethical aspects of science and technology in the domain of human health.
- Autonomously anticipate ethical issues.
- Propose and communicate solutions to ethical challenges and dilemmas.
- Identify ethical issues in life sciences and biotechnology.

Social Competencies
- Self-awareness and Self-reflection
- Critical Thinking
- Integrity and Work Ethics
-较高的技术。
- Understand the ethical theories and principles that underpin drug regulation.
- Evaluate the ethical implications of alternative pathways, such as Accelerated Approval and Compassionate Use, equipping students to assess potential benefits, risks, and societal consequences.
- Assess the ethical dimensions of drug pricing decisions and their impact on equity and accessibility, encouraging thoughtful reflection on the broader societal implications of pricing strategies.
Content
- Principles of biomedical ethics and how they relate pharmaceutical innovation
- Introduction to drug development, with a focus on the Swiss regulatory ecosystem
- Current trends and impediments to effective drug development, including the use of AI in drug discovery
- Translational medicine and its ethical implications
- Ethical aspects of pre-clinical research, including animal replacement technologies like organoids and organ chips
- Ethical aspects of clinical research
- Special regulatory pathways: expanded access / compassionate use
- Special regulatory pathways: accelerated approval
- Drug development and public health: emergency use of new drugs
- Drug pricing: introduction to its regulatory and ethical aspects

### 376-1714-00L Biocompatible Materials

#### Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

#### Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

#### Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

#### Literature

Further literature will be announced.

### 376-1720-00L Application of MATLAB in the Human Movement Sciences

#### Abstract
Students will learn to import, process and graphically present experimental data using the MATLAB computing environment. Both the data and the methods of analysis will be typical for experiments in Human Movement Science (i.e. kinematics, kinetics and electromyography).

#### Objective
Students will acquire the ability to independently load, plot, and process kinematic, kinetic and electromyographical data using the MATLAB computing environment.

#### Content
Drawbacks of Excel; Possibilities in MATLAB; Import of several data formats; Plot of one and more signals; Removing of an offset and filtering of data based on self-written functions; Normalisation and parametrisation of data; Reliability; Interpolation, Differentiation and integration in MATLAB.

#### Literature
- Handouts and references therein.

Further literature will be announced.

### 376-1721-00L Bone Biology: Basics, Research and Clinics

#### Abstract
The course gives an introduction into bone biology and provides an overview on current research methods and clinical approaches. Emphasis is put on skeletal development and metabolism, osteoporosis as well as fracture healing. Each topic is structured into three parts: basics, research and clinics.

#### Objective
After completing the Bone Biology course, students will be able to:
1. Remember and apply basics in bone biology and disease
2. Remember clinical features and surgical approaches
3. Select adequate research methods and approaches
4. Evaluate publications on topics presented in the lecture

#### Competencies
- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
- **Method-specific Competencies**
  - Communication
  - Cooperation and Teamwork
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

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Spinal Cord Injury and Exercise

Abstract
Intensive discussion concerning complications of a spinal cord injury and their consequences on trainability and exercise performance of persons sitting in a wheelchair. Overview on the clinical application of exercise testing as well as on the implementation of sport scientific findings to optimise performance of individuals with spinal cord injury in rehabilitation and elite sports.

Objective
Knowledge of the pathophysiology and the concomitant complications of a spinal cord injury and the consequences for physical exercise and trainability during rehabilitation as well as in recreational and elite sport.

Content
The following issues will be discussed: Epidemiology and etiology of spinal cord injury; complications and consequences of spinal cord injury; trainability/exercise physiology and spinal cord injury; history and organisation of wheelchair sports; elite sport and spinal cord injury.

Literature
General literature:
H.G. Koch, V. Geng
Querschnittlähmung verständlich erklärt (Band 1 und Band 2)
Selbstverlag Manfred-Sauer-Stiftung und Schweizer Paraplegiker-Vereinigung
ISBN 978-3-00-069888-0 (Band 1) und 978-3-00-069889-7 (Band 2)

G.A. Zäch, H. G. Koch
Paraplegie - ganzheitliche Rehabilitation
Karger-Verlag, 2006
ISBN 3-8055-7890-2

V. Goosney-Tolfrey
Wheelchair sport: A complete guide for athletes, coaches and teachers
Human Kinetics, 2010

Y.C. Vanlandewijck, W.R. Thompson
The Paralympic Athlete
Wiley-Blackwell, 2011
ISBN 978-1-4443-3404-3

Liz Broad
Sports Nutrition for Paralympic Athletes, Second Edition
CRC Press 2019
ISBN 978-1-38-58900-1

V.C. Vanlandewijck, W.R. Thompson
Training and Coaching the Paralympic Athlete

Colloquium in Biomechanics

Abstract
Current topics in biomechanics presented by speakers from academia and industry.

Objective
Getting insight into actual areas and problems of biomechanics.

Trauma Biomechanics

Abstract
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

Objective
Introduction to the basic principles of trauma biomechanics.

Content
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

Lecture notes
Handouts will be made available.

Literature
### Analytical Competencies

**M. Tanadini**

- Fostered: Adaptability and Flexibility

### Social Competencies

- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity assessed
- Negotiation fostered

### Personal Competencies

- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

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**376-2017-00L** Biomechanics of Sports Injuries and Rehabilitation

**K.-U. Schmitt, J. Goldhahn**

**Abstract**

This lecture introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries.

**Objective**

Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

**Content**

This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.

**Lecture notes**

Handouts will be made available.

**Literature**


**Prerequisites / notice**

A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

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**401-0629-00L** Applied Biostatistics

**M. Tanadini**

**Abstract**

This course covers the main methods used in Biostatistics. It starts by revising Linear Models (regression, Anova), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

**Objective**

After this course students:
- revised Linear Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid “biological” conclusions

**Content**

This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both, part one and two will include the following topics: exploratory data analysis, model fitting, model “selection”, residual diagnostics, model validation and results interpretation. Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analysing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

**Prerequisites / notice**

The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommend to view the online R course "etutoR".

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**551-1153-00L** Systems Biology of Metabolism

**U. Sauer, N. Zamboni**

**Number of participants limited to 15.**

**Abstract**

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

**Objective**

Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

**Content**

The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

**Lecture notes**

Script and original publications will be supplied during the course.

**Prerequisites / notice**

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

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**752-3105-00L** Physiology Guided Food Structure and Process Design

**P. A. Fischer, M. Devezeaux de Lavergne, B. von der Weid, T. Wooster**

**Abstract**

A sound understanding of physiological implications of food design will allow to shape new products, which feature health as well as environmental benefits and on the other side do not compromise on organoleptic qualities, formulation and manufacturing, and quality and safety. The course links the physiological driven requirements with food structure design and subsequent engineering steps.

**Objective**

The objective of this course is to highlight the link between human physiology, product sensory, nutritional functions, and engineering approaches to facilitate the design of food matrices reflecting the requirements for the beforementioned properties. To identify and manipulate these properties, the pathways that control the interaction of food structures and their physiological action will be introduced. Students are introduced to a skill set that will encompass basic digestion, sensory physiology knowledge, and food structures. Students will be exposed to the interplay along the gastrointestinal tract including taste, aroma, and texture perception, swallowing mechanics, and gastrointestinal digestion with an engineering or physical sciences angle.
The course introduces basic concepts of the interaction between nutrition and exercise performance.

**Subject-specific Competencies**

1. Communication
2. Creative Thinking
3. Critical Thinking
4. Integrity and Work Ethics

**Method-specific Competencies**

1. Analytical Competencies
2. Decision-making
3. Decision-making
4. Problem-solving

**Social Competencies**

1. Communication

**Personal Competencies**

1. Creative Thinking

**Competencies**

1. Concepts and Theories
2. Techniques and Technologies
3. Analytical Competencies
4. Decision-making
5. Media and Digital Technologies
6. Problem-solving
7. Project Management
8. Communication
9. Cooperation and Teamwork
10. Critical Thinking

**Abstract**

The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

**Objective**

The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

**Content**

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware of how epidemiological facts are used in prevention, practice and politics. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

**Competencies**

1. Concepts and Theories
2. Techniques and Technologies
3. Analytical Competencies
4. Decision-making
5. Media and Digital Technologies
6. Problem-solving
7. Project Management
8. Communication
9. Cooperation and Teamwork
10. Critical Thinking

**Abstract**

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

**Objective**

At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

**Content**

Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition).

**Competencies**

1. Concepts and Theories
2. Analytical Competencies
3. Decision-making

**Abstract**

The course introduces basic concepts of the interaction between nutrition and exercise performance.

**Objective**

To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

**Content**

The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

**Competencies**

1. Analytical Competencies
2. Decision-making

**Abstract**

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

**Prerequisites**

Basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

**General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on examples from chronic and infectious diseases.**

**Lecture notes**

Handouts are provided to students in the classroom.

**Lecture notes**

Lecture slides and required handouts will be available on the ETH website (moodle).

**Literature**

Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

**Prerequisites / notice**

General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

**Major in Human Health, Nutrition and Environment**

**Compulsory Courses**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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*Only for students of the Major Human Health, Nutrition*
Abstract
Writing a review paper of scientific quality on a topic in the domain of Human Health, Nutrition and Environment based on critical evaluation of scientific literature.

Objective
- Acquisition of knowledge in the field of the review paper
- Assessment of original literature as well as synthesis and analysis of the findings
- Practising of academic writing in English
- Giving an oral presentation with discussion on the topic of the review paper

Content
Topics are offered in the domains of the major ‘Human Health, Nutrition and Environment’ covering ‘Public Health’, ‘Infectious Diseases’, ‘Nutrition and Health’ and ‘Environment and Health’.

Lecture notes
Guidelines will be handed out in the beginning.

Literature
Literature will be identified based on the topic chosen.

Competencies

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<tr>
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376-0300-00L Essentials in Translational Science O 3 credits 2G J. Goldhahn

Abstract
Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicines). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

Objective
After completing this course, students will be able to understand:
- Principles of translational science including medical device development, intellectual property, regulatory environment and project management
- Students should be able to apply this knowledge in drug development programs in Pharma, Biotech or their own spin-off.

Content
What is translational science and what is it not Including:
- How to identify need?
- How to choose the appropriate research type and methodology
- How to measure success?
- How are medical devices developed?
- How to handle IP in the development process?
- How does the regulatory environment impact innovation?
- How to manage complex development projects?
- Positive and negative examples will be illustrated by distinguished guest speakers.

Literature
Principles of Biomedical Sciences and Industry
Translating Ideas into Treatments
https://doi.org/10.1002/9783527824014

Prerequisites / notice
4x online input lecture followed by case preparation and symposium

Competencies

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376-0302-01L GCP Basic Course (Modules 1 and 2) O 1 credit 1G G. Senti, C. Fila, R. Grossmann

Abstract
The basic course in “Good Clinical Practice” (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

Objective
Students will get familiar with:
- Key Ethics documents
- (International) Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data
Module 1:
Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

ECTS

W

assessed

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection

This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more

551-0223-00L

Immunology III

W

4 credits


Module: Infectious Diseases

Students majoring in Human Health, Nutrition and Environment: At least one of the courses listed in this module must be selected.

551-0223-00L

Immunology III

W

4 credits


Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1265 of 2667
Abstract
This course provides a detailed understanding of
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies
Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective
Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T cells and their effectormechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&noti=yedtii1on=1

Prerequisites
Immunology I and II recommended but not compulsory

701-0263-00L Seminar in Evolutionary Ecology of Infectious Diseases

- 3 credits
- 2G
- R. R. Regös, S. Bonhoeffer

Abstract
Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

Objective
This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

Content
A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

Lecture notes
Papers and class notes can be downloaded from a web page announced during the lecture.

Literature
Papers will be assigned and downloaded from a web page announced during the lecture.

701-1471-00L Ecological Parasitology

Does not take place this semester.

Abstract
The course will not take place fall semester 2024.

Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

Content
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria).

Practical exercises:
1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).
2. Examination of parasites in amphipods (identification and examination of effects on hosts).
3. Examination of parasitoids of aphids.

Prerequisites
The three practicals will take place at the 03.10.2023, the 17.10.2023 and the 07.11.2023 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.
Evolutionary Medicine for Infectious Diseases

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (~20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
The focus is on primary literature, but for some parts the following text books provide good background information:

- Schmid Hempel 2011 Evolutionary Parasitology
- Stearns & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Molecular Biology of Foodborne Pathogens

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antiviral intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

Module: Nutrition and Health

Students majoring in Human Health, Nutrition and Environment: At least one of the courses listed in this module must be selected.
This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products.

Lecturers
M. Siegrist

Objective
Students will be able...
- to describe heuristics that influence consumer behavior in the food domain
- to explain the consumer led food product development
- to summarise how consumers perceive the environmental impact and the healthiness of foods
- to assess the cultural, the environmental and the food policy impact on consumer behavior
- to explain psychological factors influencing eating behavior

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed
Customer Orientation assessed
Sensitivitiy to Diversity assessed

Personal Competencies
Critical Thinking assessed

Nutrition and Chronic Disease
3 credits
F. von Meyenn, M. Andersson

Abstract
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Objective
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Content
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Literature
To be provided by the individual lecturers, at their discretion.

Prerequisites / notice
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

Module: Environment and Health
Students majoring in Human Health, Nutrition and Environment: At least one of the courses listed in this module must be selected.

Number Title Type ECTS Hours Lecturers
376-1353-00L Nanostructured Materials Safety W 2 credits 2V P. Wick, T. Bürk-Thurnherr

Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

Content
Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily live. These customized nanomaterials provides extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials.

The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications and intravenous injections as well as it will provide impulses for safer material designs.

Structure of the planed lecture (2 x 45 min)

1. Introduction: the principles of nanotoxicology
2. Lung- particles interactions: two disease scenarios and their molecular mechanism
3. GI – particles interactions: intendent and unintendent particle exposure via food
4. Skin – particles interactions: body care products and their influence on skin physiology
5. intravenous injection: coloidal stability, protein corona and cellular effects
6. Micro- / Nanoplastics and development of a safety research plan
7. End of semester exam

Lecture notes
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed

Customer Orientation

Problem-solving

Decision-making

Techniques and Technologies

Concepts and Theories

Critical Thinking

Social Competencies

Cooperation and Teamwork

Focus on Medical Technology

Compulsory Courses

Number Title Type ECTS Hours Lecturers
376-0300-00L Essentials in Translational Science O 3 credits 2G J. Goldhahn

Abstract
Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicines). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

Objective
After completing this course, students will be able to understand:
Principles of translational science including medical device development, intellectual property, regulatory environment and project management

Students should be able to apply this knowledge in drug development programs in Pharma, Biotech or their own spin-off.
### Content
What is translational science and what is it not Including:
- How to identify need?
- How to choose the appropriate research type and methodology
- How to measure success?
- How are medical devices developed?
- How to handle IP in the development process?
- How does the regulatory environment impact innovation?
- How to manage complex development projects?
Positive and negative examples will be illustrated by distinguished guest speakers.

### Literature
- Principles of Biomedical Sciences and Industry
- Translating Ideas into Treatments
  https://doi.org/10.1002/9783527824014

### Prerequisites / notice
4x online input lecture followed by case preparation and symposium

### Competencies
- **Subject-specific Competencies**
  - Concepts and Theories assessed
  - Techniques and Technologies fostered
- **Method-specific Competencies**
  - Analytical Competencies assessed
  - Decision-making assessed
  - Problem-solving assessed
  - Project Management fostered
- **Social Competencies**
  - Communication fostered
  - Cooperation and Teamwork fostered
  - Customer Orientation fostered
  - Negotiation fostered
- **Personal Competencies**
  - Adaptability and Flexibility fostered
  - Creative Thinking fostered
  - Critical Thinking assessed
  - Integrity and Work Ethics fostered
  - Self-awareness and Self-reflection fostered
  - Self-direction and Self-management fostered

### 376-0302-01L GCP Basic Course (Modules 1 and 2)
- **Objective**
  - Students will get familiar with:
    - Key Ethics documents
    - (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
    - Sequence of research projects and project-involved parties
    - Planning of research projects (statistics, resources, study design, set-up of the study protocol)
    - Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
    - Roles and responsibilities of project-involved parties
  - Students will learn how to:
    - Classify research projects according the risk-based approach of the HRA
    - Write a study protocol
    - Inform participating patients/study subjects
    - Obtain consent by participating patients/study subjects
    - Classify, document and report Adverse Events
    - Handle projects with biological material from humans and/or health-related personal data

### Elective Courses

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<th>Number</th>
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<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
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### Abstract
**Microrobotics** is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

### Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

### Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobotics

### Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

### Prerequisites / notice
The lecture will be taught in English.
Introduction to Biomedical Engineering

Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Prerequisites / notice

No specific requirements, BUT HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.). ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

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Prerequisites / notice

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Summary, example exam questions

- Identification of basic imaging principles
- Design of basic diagnostic imaging systems
- Characterization of imaging systems
- Analysis of imaging modality advantages and limitations
- Explanations of imaging fundamentals

Content

- Introduction to biomedical engineering
- History of BME and the role of biomedical engineers
- Ethical issues related to BME
- Biomedical sensors: wearable sensors and biochemical sensors
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices
- Bioinformatics: genomic and proteomic tools, databases and basic calculations
- Equations describing basic reactions and enzyme kinetics
- Medical optics: optical components and systems used in hospitals
- Basic concepts of tissue engineering and organ printing
- Biomaterials and their medical applications
- Function of the heart and the circulatory system
- Transport and exchange of substances in the human body, compartment modeling
- The respiratory system
- Bioimaging
- Orthopedic biomechanics
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes

Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

Lecture notes

Lecture notes and handouts

Literature

Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming
### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### 227-0393-10L Bioelectronics and Biosensors

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<tr>
<th>Credit</th>
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<th>Lecturer</th>
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<tr>
<td>6</td>
<td>Bioelectronics and Biosensors</td>
<td>J. Vörös, M. F. Yanik</td>
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#### Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

#### Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

#### Content

1. Introduction

2. Sources of bioelectronic signals

3-4. Action potential and Hodgkin-Huxley

5. Measuring bioelectronic signals

6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes

7. Measuring potentials in solution and core conductance model

8. Measuring electronic signals with wearable electronics, ECG, EEG

9. Measuring mechanical signals with bioelectronics

10. In vivo stimulation and recording

11. Functional electric stimulation

12. In vivo electrophysiology

13. Optical recording and control of neurons (optogenetics)

14. Measuring biochemical signals

#### Literature
- Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

#### Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

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- Techniques and Technologies

Method-specific Competencies
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- Media and Digital Technologies
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Image Analysis and Computer Vision

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Image Analysis and Computer Vision

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Communication

- Information transfer and communication in computer systems
- Communication protocols and standards

Analytical Competencies

- Mathematical foundations of image processing
- Linear and non-linear filters
- Image segmentation
- Image enhancement

Social Competencies

- Teamwork and collaboration
- Leadership and management
- Communication and negotiation

Personal Competencies

- Adaptability and flexibility
- Critical thinking
- Integrity and work ethics

Cell Biophysics

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Cell Biophysics

Abstract

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective

- Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics copring with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Content

- Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Lecture notes

- Theory and corresponding exercises are merged together during the classes.

No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o’clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!

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As further deepening:


Prerequisites / notice

- Participants need a good command of differentiation and integration of a function with one or more variables (basics of Analysis), Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

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227-0965-00L Micro and Nano-Tomography of Biological Tissues


The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

227-0969-00L Methods & Models for fMRI Data Analysis


The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes

Available online

263-5057-00L From Publication to the Doctor’s Office


This seminar course is designed to provide students with an opportunity to review and critically evaluate recent publications in medical field focusing on examples when CS method or bioinformatics/statistical technique has lead to an instrumentation, technique or drug approved for clinical practice use.

Throughout the course, students will read and analyze recent publications that demonstrate successful applications and sometimes failures in medicine. Promising research applications will also be discussed. The publications will cover a wide range of topics, including drug discovery, image analysis, prognostic models, and learning healthcare.
Content
The course will be structured as half lecture content and half seminar content. Lectures will review state of the medical practice prior to the
discovery, obstacles in moving the field forward, and the need for improvement. Lecture will be followed by the seminar part where
students will take turns presenting the assigned publications and leading the discussions. Students' presentations will focus on the main
findings, and specific steps taken to translate the finding into clinical practice.

Publications will include examples of:
- specific CS/bioinformatics/statistics applications that has been brought to “bedside” – has been approved by European Medicines Agency
Food and Drug Administration (USA) for clinical use or are widely used in medical research;
- examples of failures of how a discovery did not translate into an endproduct and why;
current active research areas.

Covered topics will include some of the following:
- Drug discovery: Computer-aided drug discovery has become an integral part of the drug development process, enabling researchers to
design and screen large libraries of molecules in silico (i.e., using computer simulations) before synthesizing and testing them in the lab.
This has led to the discovery of new drug candidates for a wide range of diseases, including cancer, Alzheimer’s disease, and HIV/AIDS.
- Genomics: Advances in computational genomics have enabled researchers to analyze and interpret large-scale genomic data, including
DNA sequencing data, to identify disease-causing mutations, genetic risk factors, and drug targets. Examples of the development of
personalized medicine, where treatments are tailored to an individual’s genetic makeup. Examples when drug target identified by genetics
has led to approved treatment.
- Imaging: Computer vision and image processing techniques have revolutionized medical imaging, enabling researchers to extract
quantitative information from medical images that were previously inaccessible. This has led to the development of new diagnostic
and prognostic tools for a wide range of diseases, including cancer, cardiovascular disease, and neurological disorders.
- Real-world data applications: Emulation of clinical trials using electronic health records data.
- Large language models: Generating clinical trial protocols using large language models. Natural Language Processing for information
extraction and interpretation.
- Learning healthcare systems: Advances in data analytics and information technology have enabled the development of learning
healthcare systems, which use real-time data from electronic health records, medical devices, and other sources to improve patient
outcomes and reduce healthcare costs. This has the potential to transform the way healthcare is delivered, making it more personalized,
efficient, and effective.

In addition to the presentations, students will also be required to write critical reviews of the assigned publications throughout the course.
The reviews will be evaluated based on the students’ ability to identify the strengths and weaknesses of the publications and to provide
insightful and constructive feedback.

Prerequisites /notice
The course is intended for advanced undergraduate and graduate students with a background in computer science, bioinformatics, or a
related field and interest in applying their skills to medical research.

This course assumes a working knowledge of R/Python and intermediate statistical analysis, including linear, logistic, survival regressions
or ability and interest to learn them outside of the class.

Competencies
- Subject-specific Competencies
  - Concepts and Theories: fostered
  - Techniques and Technologies: fostered
- Method-specific Competencies
  - Analytical Competencies: fostered
- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: fostered
  - Leadership and Responsibility: fostered
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: fostered
- Personal Competencies
  - Creative Thinking: fostered
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered

Abstract
This course teaches the basics of surface and interface science and technology, including surface modifications and forces. It covers
various analytical techniques to study surface and interface properties, and explores phenomena of applied relevance like friction,
lubrication, phoresis, and wetting where surfaces play a crucial role.

Objective
Students are able to
- describe the physical and chemical properties of surfaces and interfaces.
- analyze and compare analytical tools for surfaces,
- choose and combine appropriate surface-analytical approaches for solving problems connected to applications.
- understand and explain the importance of surfaces and interfaces in a broad range of phenomena and applications.

Content
- Introduction to surfaces and interfaces
- Structure of surfaces over different length scales: from macroscopic roughness to atomic structure
- Surface modifications
- Adsorption and adsorption models
- Surface forces
- Basic physical concepts
- Thermodynamics of surfaces and interfaces
- Measurement of intermolecular and surface forces
- Dynamics and history effects
- Surface analytics: X-ray Photoelectron Spectroscopy (XPS) – principles and modern developments
- Surface analytics: Secondary Ion Mass Spectroscopy (SIMS) and IR Spectroscopy – Principles and examples
- Atomic Force Microscopy (AFM): Principles and modes of operation
- Tribology: Adhesion, Friction and Lubrication
- Contact mechanics
- Micro and macroscale friction
- Boundary lubrication
- Wetting
- Contact angles
- Phoretic phenomena
- Electric double layer and electrophoresis
- Electro-osmosis
- Other types of phoresis
- Case studies

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1274 of 2667
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.
**Objective**

Understanding of
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

**Content**

**Lectures:**
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

**Practicals:**
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

**Literature**


**Prerequisites / notice**

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

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**Technology Entrepreneurship**

<table>
<thead>
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<td>Technology Entrepreneurship</td>
<td>W 2 credits 2V</td>
<td>F. Hacklin</td>
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**Abstract**

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

**Objective**

Weekly sessions - recorded.

10+ sessions carried out by guest lecturers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …). Final session: multiple choice semester assignment (100% of grade).

Typical lecture format (2h):
15': Introduction
60': Guest testimonial
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

**Lecture notes**

Lecture slides and case material

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Analytical Competencies
- Problem-solving

**Method-specific Competencies**
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

**Social Competencies**
- Fostered

**Personal Competencies**
- Critical Thinking

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**Developing Digital Biomarkers**

<table>
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<td>363-1163-00L</td>
<td>Developing Digital Biomarkers</td>
<td>W 3 credits 2V</td>
<td>F. Da Conceição Barata</td>
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</table>

**Abstract**

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

**Objective**

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world's aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:
- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker
The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as "deep learning") have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

Competencies

Subject-specific Competencies

Methods and Technologies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Problem-solving

Communication

Cooperation and Teamwork

Self-presentation and Social Influence

Creative Thinking

Critical Thinking

Self-direction and Self-management

Method-specific Competencies

Social Competencies

Personal Competencies

376-0021-00L

Materials and Mechanics in Medicine

W

4 credits

3G

M. Zenobi-Wong, J. G. Snedeker

Abstract

Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomechanical applications in research and clinical practice.

Objective

Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomechanical applications in research and clinical practice.

Content

Biomaterials, Tissue Engineering, Tissue Biomachines, Implants.

Lecture notes

course website on Moodle

Literature

Introduction to Biomedical Engineering, 3rd Edition 2011.

Autumn Semester 2024

376-0121-00L

Multiscale Bone Biomechanics

W

6 credits

3S

R. Müller, X.-H. Qin

Abstract

The seminar provides state-of-the-art insight into the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

Objective

The learning objectives include

1. advanced knowledge of the state-of-the-are in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programing skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.
Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions courses focused on Quality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A).

Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

#### 376-0208-00L Molecular and Cellular Biology of Exercise and Muscle Regeneration - Practical Aspects

**Prerequisites:**
Laboratory Course in Molecular Biology (376-0006-02L)

**Content**
The skeletal muscle biology field purposes to understand how muscles coordinate movement, regenerate following injury and adapt to exercise stimuli. In this course, the students will acquire insights into the molecular aspects of muscle biology and exercise, in addition to gaining hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise.

**Objective**
The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

**Abstract**
The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students- each one will focus on one of the following research topics:

- **Topic 1:** Molecular pathways that control muscle stem cell self-renewal and differentiation
- **Topic 2:** Genome engineering to correct genetic mutations that cause muscle diseases
- **Topic 3:** Muscle fiber composition, force production and insulin sensitivity
- **Topic 4:** Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session.

For the journal club, each group of students will receive a peer-review article that is highly relevant to the respective group’s research topic. Each of the 4 groups will present and discuss the article in a journal club format to the rest of the participants the following week. During the four practical sessions, students will gain hands-on experiences and learn different lab techniques related to molecular biology of exercise and muscle regeneration. Each group will be presented with a research objective that is related to their topic, and perform in collaboration with teaching assistants a set of experiments that aim to address the research objective. At the final evaluation session, each group of students will present their results and identify follow-up research questions and hypothesis based on their experimental achievements.

Select practical methods that the proposed course will teach include:

1. **Group 1:** tissue culture, isolation of muscle stem cells via FACs, differentiation of muscle stem cells into muscle fibers, small molecules screens, quantitative analysis of muscle cell proliferation and fusion, immunofluorescence
2. **Group 2:** tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crispr-Cas9 gene editing of genetic mutations that cause muscle diseases in muscle stem cells and fibers. Immunofluorescence and PCR.
3. **Group 3:** ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, immunofluorescence and western blot.
4. **Group 4:** tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers. Western blot.

**Prerequisites:**
Laboratory Course in Molecular Biology

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The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

- Students should develop and evaluate research hypotheses for a specific research topic
- Apply universal good clinical practice guidelines in future research projects
- Integrate well-documented data management and open science principles into future research projects
- Integrate principles of effective communication in speaking, writing and graphical illustrations of future research idea/output

This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart rate, blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

For D-HEST Master's and PhD students:
- Course prerequisites:
  - For Biomedical Engineering Master's: none
  - For ITET Master's: none
  - If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)
  - If BSc in electrical/mechanical engineering or computer science: none
  - If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)
- File, metafiles)
- Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metadata)
- FAIR principles and open science
- Design principles and free digital tools for graphical illustrations
- Effective summarizing of research output/topic in an abstract and pitch presentation

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will provide students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the-art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

Objective 1:
- Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2:
- Acquire skills to design novel non-invasive technologies for sport and health.

The course consists of two modules.

Module 1: Movement.
This module provides the scientific background needed to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies.

Module 2: Cardio.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies and the latest data analysis techniques to monitor the cardiac cycle for assisting individuals in sport activities or monitoring their health conditions.

- Students should be proficient in programming (any language).
- Course prerequisites:
  - For Biomedical Engineering Master’s: none
  - For ITET Master’s: none
  - For D-MAVT Master’s: none
  - For D-HEST Master’s and PhD students:
    - If BSc in electrical/mechanical engineering or computer science: none
    - If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)
Abstract
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.

Objective
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

376-1179-00L Applications of Cybernetics in Ergonomics
W 1 credit 1U M. Menozzi Jäckli, Y.- Y. Hedinger Huang, R. Huang

Abstract
Cybernetics systems have been studied and applied in various research fields, such as for applications in ergonomics. Topics discussed in this lecture (man-machine-interaction, performance in multi-modal interactions, quantification in gestalt principles for the use in product development, information processing) are deepened with exercises conducted at our labs.

Objective
To learn and practice cybernetics principles in interface designs and product development.

Content
- Fitt's law applied in manipulation tasks
- Hick-Hyman law applied in design of the driver assistance systems - Vigilance applied in quality inspection
- Accommodation/vergence crosslink function
- Cross-link models in neurobiology- the ocular motor control system
- Human performance in optimization of production lines

Literature

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions
W 3 credits 2V R. Riener, O. Lambercy

Abstract
Rehabilitation Engr is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Content
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces
Literature

Introductory Books:


Selected Journal Articles and Web Links:


Prerequisites / notice

Target Group:
- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich

Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Competencies

<table>
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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Problem-solving</td>
<td>Media and Digital Technologies</td>
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Abstract

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.
Objective

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

Content

Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- 2 × 45 min will be covered by Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, who will present how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Social Competencies
- Communication fostered

Personal Competencies
- Critical Thinking assessed
- Integrity and Work Ethics fostered

376-1353-00L Nanostructured Materials Safety W 2 credits 1V P. Wick, T. Bürki-Thurnherr

Abstract

Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.

Objective

Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily live. These customized nanomaterials provides extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials.

The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- 2 × 45 min will be covered by Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, who will present how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone

376-1504-00L Physical Human Robot Interaction (pHRI) ■ W 4 credits 2V+2U O. Lamberty, P. Wolf

Abstract

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.
The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Will be distributed on Moodle before the lectures.


The registration is limited to 26 students.
There are 4 credit points for this lecture.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes.
http://www.relab.ethz.ch/education/courses/phri.html
## Practical Methods in Tissue Engineering

**W 5 credits 4P**

M. Zenobi-Wong, S. J. Ferguson, fostered

### Abstract
The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

### Objective
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

### Prerequisites / notice
A laptop is needed with the below Systems Requirements:
- Memory: 16 GB
- Processor: 3rd gen i7
- DirectX® 11.0 compliant AMD Radeon/NVIDIA® GeForce® card with 2 GB RAM
- Storage: 15 GB

Mac computer can be used by pre-installing Windows through bootcamp (older Macs) or Parallels Desktop (14d trial license, 35 CHF license purchasable in the IT shop of ETH).

## Clinical and Movement Biomechanics

**W 4 credits 3G**

D. K. Ravi, S. H. Hosseini Nasab, R. List, fostered

### Abstract
Measurement and modeling of the human movement during daily activities and in a clinical environment.

### Objective
The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

### Content
This course includes study design, measurement techniques, clinical testing, accessing movement data and analysis as well as modeling with regards to human movement.

## Ethics of Life Sciences and Biotechnology

**W 3 credits 2V**

A. Blasimme, E. Vayena

### Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

### Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

- A. Identify ethical issues in in life sciences and biotechnology.
- B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
- C. Become aware of relevant legal and public policy frameworks.
- D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
- E. Recognize how ethical issues relate to different accounts of technology and innovation.
- F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
- G. Autonomously anticipate ethical issues.
- H. Propose and communicate solutions to ethical challenges and dilemmas.

### Content
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.
376-1664-00L Ethics in Drug Development W 3 credits 2V A. Blasimme, E. Vayena, to be announced

Abstract This course provides a thorough exploration of drug development and involved ethical issues as well as critical analysis of ethical challenges and practical skills to resolve them. It includes elements of drug discovery, preclinical and clinical research ethics, alternative regulatory pathways and ethics of drug pricing and develops a solid grasp of ethical complexity as well as practical skills.

Objective This course is tailored to D-HEST students who want to become familiar with pharmaceutical development and its ethical implications. By the end of this course, students will have developed a comprehensive understanding of the ethical complexities and challenges in drug development. They will be equipped with the knowledge and analytical skills to navigate ethical reasoning and contribute to the responsible advancement of pharmaceutical research. The specific learning objectives of the course are:

- Discuss relevant legal and public policy frameworks in drug development, ensuring an understanding of the broader regulatory context within which policy and regulatory decisions are made.
- Recognize and identify ethical dilemmas inherent to drug development, fostering a heightened awareness of ethical considerations across various stages of the process.
- Identify and discuss ethical issues in drug development in light of recent advances in the field of artificial intelligence.
- Critically analyze ethical challenges within drug development, enabling them to discuss complex issues, evaluate competing ethical perspectives, and form reasoned judgments.
- Understand the ethical theories and principles that underpin drug regulation.
- Evaluate the ethical implications of alternative pathways, such as Accelerated Approval and Compassionate Use, equipping students to assess potential benefits, risks, and societal consequences.
- Assess the ethical dimensions of drug pricing decisions and their impact on equity and accessibility, encouraging thoughtful reflection on the broader societal implications of pricing strategies.

Content - Principles of biomedical ethics and how they relate pharmaceutical innovation
- Introduction to drug development, with a focus on the Swiss regulatory ecosystem
- Current trends and impediments to effective drug development, including the use of AI in drug discovery
- Translational medicine and its ethical implications
- Ethical Aspects of pre-clinical research, including animal replacement technologies like organoids and organ chips
- Ethical aspects of clinical research
- Special regulatory pathways: accelerated access / compassionate use
- Special regulatory pathways: accelerated approval
- Drug development and public health, emergency use of new drugs
- Drug pricing: introduction to its regulatory and ethical aspects

376-1714-00L Biocompatible Materials W 4 credits 3V K. Maniura, M. Rottmar, M. Zenobi-Wong

Abstract Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, bio degradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes Literature
Handouts are deposited online (moodle).

- Handouts and references therin.
- Literature:

(available online via ETH library)

376-1721-00L Bone Biology: Basics, Research and Clinics W 2 credits 2V E. Wehrle, G. A. Kuhn, to be announced

Abstract The course gives an introduction into bone biology and provides an overview on current research methods and clinical approaches. Emphasis is put on skeletal development and metabolism, osteoporosis as well as fracture healing. Each topic is structured into three parts: basics, research and clinics.

Objective After completing the Bone Biology course, students will be able to:
1. Remember and apply basics in bone biology and disease
2. Remember clinical features and surgical approaches
3. Select adequate research methods and approaches
4. Evaluate publications on topics presented in the lecture
Adaptability and Flexibility fostered

Getting insight into actual areas and problems of biomechanics.

Concepts and Theories assessed
Techniques and Technologies fostered

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Communication fostered
Cooperation and Teamwork assessed
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered

Sensitivity to Diversity fostered
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered

Sensitivity to Diversity assessed
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

376-1985-00L Trauma Biomechanics W 4 credits 2V+1U K.-U. Schmitt, M. H. Muser

Abstract
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

Objective
Introduction to the basic principles of trauma biomechanics.

Content
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

Lecture notes
Handouts will be made available.

Literature


Abstract
Current topics in biomechanics presented by speakers from academia and industry.

Objective
Getting insight into actual areas and problems of biomechanics.

401-0629-00L Applied Biostatistics W 4 credits 3G M. Tanadini

Abstract
This course covers the main methods used in Biostatistics. It starts by revising Linear Models (Regression, Anova), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

Objective
After this course students:
- revised Linear Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions

Content
This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both, part one and two will include the following topics: exploratory data analysis, model fitting, model "selection", residual diagnostics, model validation and results interpretation.

Prerequisites / notice
The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommend to view the online R course "etutoR".
Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

Objective
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein adsorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultraviolet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

<table>
<thead>
<tr>
<th>529-0041-00L</th>
<th>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</th>
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<tbody>
<tr>
<td>W</td>
<td>6 credits</td>
</tr>
<tr>
<td>3G</td>
<td>R. Zenobi, B. Hattendorf</td>
</tr>
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<td>P. Sinués Martinez-Lozano</td>
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</table>

| Abstract | Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics. |
| Content  | Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics). |

| Literature | Information about relevant literature will be available in the lecture & in the lecture notes. |
| Notice     | Exercises are an integral part of the lecture. |

| Prerequisites / notice | 529-0051-00 "Analytische Chemie I (3. Semester)" |
|                      | 529-0058-00 "Analytische Chemie II (4. Semester)" |
|                      | (or equivalent) |

| Competencies | Subject-specific Competencies |
|             | Concepts and Theories |
|             | Techniques and Technologies |

| Competencies | Method-specific Competencies |
|             | Analytical Competencies |
|             | Decision-making |
|             | Media and Digital Technologies |
|             | Problem-solving |
|             | Project Management |

| Competencies | Social Competencies |
|             | Communication |
|             | Cooperation and Teamwork |
|             | Customer Orientation |
|             | Leadership and Responsibility |
|             | Self-presentation and Social Influence |
|             | Sensitivity to Diversity |
|             | Negotiation |

| Competencies | Personal Competencies |
|             | Adaptability and Flexibility |
|             | Creative Thinking |
|             | Critical Thinking |
|             | Integrity and Work Ethics |
|             | Self-awareness and Self-reflection |
|             | Self-direction and Self-management |

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<thead>
<tr>
<th>529-0042-00L</th>
<th>Drug Delivery and Drug Targeting</th>
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<tbody>
<tr>
<td>W</td>
<td>2 credits</td>
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<td>1.5V</td>
<td>J.-C. Leroux</td>
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| Abstract | The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria. |
| Content  | The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems. |

| Lecture notes | Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website. |
Further references will be provided in the course.

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<tr>
<th>Course Code</th>
<th>Title</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>M. Kopf, A. Oxenius</th>
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<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
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<table>
<thead>
<tr>
<th>Abstract</th>
<th>Introduction into structural and functional aspects of the immune system.</th>
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<tbody>
<tr>
<td>Objective</td>
<td>Basic knowledge of the mechanisms and the regulation of an immune response.</td>
</tr>
<tr>
<td>Content</td>
<td>Introduction into structural and functional aspects of the immune system.</td>
</tr>
</tbody>
</table>

- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

<table>
<thead>
<tr>
<th>Literature</th>
<th>- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisites /</td>
<td>For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.</td>
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<th>Competencies</th>
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<tr>
<th>Course Code</th>
<th>Title</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>U. Kutay, F. Allain, T. Kleele, I. Zemp</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>U. Kutay, F. Allain, T. Kleele, I. Zemp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division &amp; growth, and cell migration.</th>
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<tbody>
<tr>
<td>Objective</td>
<td>The full-year course (551-0319-00 &amp; 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.</td>
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<tr>
<td>Content</td>
<td>Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.</td>
</tr>
</tbody>
</table>

| Lecture notes        | Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alia.smith@bc.biol.ethz.ch) |
636-0108-00L Biological Engineering and Biotechnology

**Abstract**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objective**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content**

**Lecture notes**
Handout during the course.

752-3105-00L Physiology Guided Food Structure and Process Design

**Abstract**
A sound understanding of physiological implications of food design will allow to shape new products, which feature health as well as environmental benefits and on the other side do not compromise on organoleptic qualities, formulation and manufacturing, and quality and safety. The course links the physiological driven requirements with food structure design and subsequent engineering steps.

**Objective**
The objective of this course is to highlight the link between human physiology, product sensory, nutritional functions, and engineering approaches to facilitate the design of food matrices reflecting the requirements for the beforementioned properties. To identify and manipulate these properties, the pathways that control the interaction of food structures and their physiological action will be introduced. Students are introduced to a skill set that will encompass basic digestion, sensory physiology knowledge, and food structures. Students will be exposed to the interplay along the gastrointestinal tract including taste, aroma, and texture perception, swallowing mechanics, and gastrointestinal digestion with an engineering or physical sciences angle.

**Content**
Chapter 1: Introduction - The need for physiology guided structure and process design in the context of personalized nutrition (Peter Fischer)
Chapter 2: Food Oral Processing: the impact of food oral breakdown on sensory perception (Marine Devezeaux de Lavergne)
Chapter 3: Chewing and swallowing across the lifespan, from infants to elderly (Marine Devezeaux de Lavergne)
Chapter 4: Perception physiology in humans and other species (Benot von der Weid)
Chapter 5: Biophysics of food digestion & how it can be exploited in the development of strategies for delivery (Timothy J. Wooster)
Chapter 6: Numerical and experimental modelling of the intestinal system (Peter Fischer)

**Lecture notes**
Lecture notes are available at Moodle.

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving

- Social Competencies
  - Communication

- Personal Competencies
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics

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**Major in Molecular Health Sciences**

**Compulsory Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-0300-00L</td>
<td>Essentials in Translational Science</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>J. Goldhahn</td>
</tr>
</tbody>
</table>

**Abstract**
Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicines). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

**Objective**
After completing this course, students will be able to understand:
- Principles of translational science including medical device development, intellectual property, regulatory environment and project management
- Students should be able to apply this knowledge in drug development programs in Pharma, Biotech or their own spin-off.

**Content**
- What is translational science and what is it not including:
  - How to identify need?
  - How to choose the appropriate research type and methodology
  - How to measure success?
  - How and medical device developed?
  - How to handle IP in the development process?
  - How does the regulatory environment impact innovation?
  - How to manage complex development projects?
- Positive and negative examples will be illustrated by distinguished guest speakers.

**Literature**
- Principles of Biomedical Sciences and Industry
- Translating Ideas into Treatments
  - https://doi.org/10.1002/9783527824014

**Prerequisites / notice**
4x online input lecture followed by case preparation and symposium
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

376-0302-01L GCP Basic Course (Modules 1 and 2) O 1 credit 1G G. Senti, C. Fila, R. Grossmann

Abstract
The basic course in "Good Clinical Practice" (GCP) contains two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

Objective
Students will get familiar with:
- Key Ethics documents
- (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

Content
Module 1:
- Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator’s Brochure, Patient Information Leaflet, Informed Consent Form)
Module 2:
- Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

Elective Courses

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0939-00L</td>
<td>Cell Biophysics</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>T. Zambelli</td>
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Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective
Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content
- Basics of theory of probability
- Boltzmann’s law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns

Theory and corresponding exercises are merged together during the classes.
Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o'clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!

Literature


As further deepening:


Prerequisites / notice

Participants need a good command of

• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Competencies

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<tr>
<th>Competencies</th>
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<td>Project Management</td>
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W 3 credits 2S+1A O. Demler

263-5057-00L From Publication to the Doctor's Office

Abstract

This seminar course is designed to provide students with an opportunity to review and critically evaluate recent publications in medical field focusing on examples when CS method or bioinformatics/statistical technique has lead to an instrumentation, technique or drug approved for clinical practice use.

Objective

Throughout the course, students will read and analyze recent publications that demonstrate successful applications and sometimes failures in medicine. Promissing research applications will also be discussed. The publications will cover a wide range of topics, including drug discovery, image analysis, prognostic models, and learning healthcare.
The course will be structured as half lecture content and half seminar content. Lectures will review state of the medical practice prior to the current active research areas. 

Covered topics will include some of the following:
- Drug discovery: Computer-aided drug discovery has become an integral part of the drug development process, enabling researchers to design and screen large libraries of molecules in silico (i.e., using computer simulations) before synthesizing and testing them in the lab. This has led to the discovery of new drug candidates for a wide range of diseases, including cancer, Alzheimer's disease, and HIV/AIDS.
- Genomics: Advances in computational genomics have enabled researchers to analyze and interpret large-scale genomic data, including DNA sequencing data, to identify disease-causing mutations, genetic risk factors, and drug targets. Examples of the development of personalized medicine, where treatments are tailored to an individual's genetic makeup. Examples when drug target identified by genetics has led to approved treatment.
- Imaging: Computer vision and image processing techniques have revolutionized medical imaging, enabling researchers to extract quantitative information from medical images that were previously inaccessible. This has led to the development of new diagnostic and prognostic tools for a wide range of diseases, including cancer, cardiovascular disease, and neurological disorders.
- Real-world data applications: emulation of clinical trials using electronic health records data.
- Large language models: Generating clinical trial protocols using large language models. Natural Language Processing for information extraction and interpretation.
- Learning healthcare systems: Advances in data analytics and information technology have enabled the development of learning healthcare systems, which use real-time data from electronic health records, medical devices, and other sources to improve patient outcomes and reduce healthcare costs. This has the potential to transform the way healthcare is delivered, making it more personalized, efficient, and effective.

In addition to the presentations, students will also be required to write critical reviews of the assigned publications throughout the course. The reviews will be evaluated based on the students' ability to identify the strengths and weaknesses of the publications and to provide insightful and constructive feedback.

Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopEM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lectures:
Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
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- Practice on real-world samples and report results

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.
Objective

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:
- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

376-0121-00L Multiscale Bone Biomechanics W 6 credits 3S R. Müller, X.-H. Qin

Abstract

The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

Objective

The learning objectives include
1. advanced knowledge of the state-of-the-are in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programing skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.
Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions courses focused on QUality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom approach. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A). Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

### 376-0208-00L Molecular and Cellular Biology of Exercise and Muscle Regeneration - Practical Aspects

**W** 3 credits **2G**, **O. Bar-Nur**, **K. De Bock**

**Prerequisites:** Laboratory Course in Molecular Biology (376-0006-02L)

**Abstract**
The skeletal muscle biology field purposes to understand how muscles coordinate movement, regenerate following injury and adapt to exercise stimuli. In this course, the students will acquire insights into the molecular aspects of muscle biology and exercise, in addition to gaining hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise.

**Objective**
The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

**Content**
The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students- each one will focus on one of the following research topics:

1. **Topic 1:** Molecular pathways that control muscle stem cell self-renewal and differentiation
   - Genotype and phenotype in cell development
   - Stem cell differentiation and differentiation in muscle regeneration

2. **Topic 2:** Genome engineering to correct genetic mutations that cause muscle diseases
   - Genotyping and genome editing in muscle disease
   - CRISPR-Cas9 gene editing
   - Gene editing for disease correction

3. **Topic 3:** Muscle fiber composition, force production and insulin sensitivity
   - Muscle fiber composition
   - Force production and insulin sensitivity
   - Insulin resistance and muscle dysfunction

4. **Topic 4:** Amino acid sensitivity in skeletal muscle following exercise
   - Amino acid metabolism in skeletal muscle
   - Exercise-induced amino acid sensitivity
   - Exercise response and muscle function

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session.

For the journal club, each group of students will receive a peer-review article that is highly relevant to the respective group’s research topic. Each of the 4 groups will present and discuss the article in a journal club format to the rest of the participants the following week. During the four practical sessions, students will gain hands-on experiences and learn different lab techniques related to molecular biology of exercise and muscle regeneration. Each group will be presented with a research objective that is related to their topic, and perform in collaboration with teaching assistants a set of experiments that aim to address the research objective. At the final evaluation session, each group of students will present their results and identify follow-up research questions and hypothesis based on their experimental achievements.

Select practical methods that the proposed course will teach include:

1. **Group 1:** Tissue culture, isolation of muscle stem cells via FACs, differentiation of muscle stem cell into muscle fibers, small molecules screens, quantitative analysis of muscle cell proliferation and fusion, Immunofluorescence
2. **Group 2:** Tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crispr-Cas9 gene editing
3. **Group 3:** ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, immunofluorescence and western blot
4. **Group 4:** Tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers, Western blot

**Prerequisites:**

376-0006-02L Laboratory Course in Molecular biology
Practical Methods in Tissue Engineering

Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were fostered, getting insight into actual areas and problems of translational medicine. S. J. Ferguson, 1K

Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide analytical competencies.

Analytical Competencies

Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on

Communication

Concepts and Theories

Subject-specific Competencies

The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

Social Competencies

Fostering a personal and critical attitude towards the ethical aspects of life sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the domain of human health. The specific learning objectives of this course are:

1. Propose and communicate solutions to ethical challenges and dilemmas.
2. Autonomously anticipate ethical issues.
3. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
4. Recognize how ethical issues relate to different accounts of technology and innovation.
5. Become aware of relevant legal and public policy frameworks.
6. Analyze and critically discuss ethical issues in life sciences and biotechnology.
7. Understand the principles of nanotoxicology.
8. Study the principles of nanotoxicology and provide the understanding of the potential side effects of nanomaterials in contexts-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications, and intravenous injections as well as it will provide impulses for safer material designs.
9. Structure the planned lecture (2 x 45 min)

1. Introduction: the principles of nanotoxicology
2. Lung-particles interactions: two disease scenarios and their molecular mechanism
3. GI-particles interactions: intendent and unintended particle exposure via food
4. Skin-particles interactions: body care products and their influence on skin physiology
5. Intravenous injection: colloidal stability, protein corona and cellular effects
6. Micro-/ Nanoplastics and development of a safety research plan
7. End of semester exam

Licence

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences

Objective

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

1. Identify ethical issues in life sciences and biotechnology.
2. Analyze and critically discuss ethical issues in life sciences and biotechnology.
3. Become aware of relevant legal and public policy frameworks.
4. Distinguish different ethical approaches and argumentative strategies in applied ethics.
5. Recognize how ethical issues relate to different accounts of technology and innovation.
6. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
7. Autonomously anticipate ethical issues.
8. Propose and communicate solutions to ethical challenges and dilemmas.
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

**Method-specific Competencies**
- Techniques and Technologies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

**Social Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

**Personal Competencies**
- Self-awareness and Self-reflection

**Content**

**376-1664-00L Ethics in Drug Development**

**Abstract**

This course provides a thorough exploration of drug development and involved ethical issues as well as critical analysis of ethical challenges and practical skills to resolve them. It includes elements of drug discovery, preclinical and clinical research ethics, alternative regulatory pathways and ethics of drug pricing and develops a solid grasp of ethical complexity as well as practical skills.

**Objective**

This course is tailored to D-HEST students who want to become familiar with pharmaceutical development and its ethical implications. By the end of this course, students will have developed a comprehensive understanding of the ethical complexities and challenges in drug development. They will be equipped with the knowledge and analytical skills to navigate ethical reasoning and contribute to the responsible advancement of pharmaceutical research. The specific learning objectives of the course are:

- Discuss relevant legal and public policy frameworks in drug development, ensuring an understanding of the broader regulatory context within which policy and regulatory decisions are made.
- Recognize and identify ethical dilemmas inherent to drug development, fostering a heightened awareness of ethical considerations across various stages of the process.
- Identify and discuss ethical issues in drug development in light of recent advances in the field of artificial intelligence.
- Critically analyze ethical challenges within drug development, enabling them to discuss complex issues, evaluate competing ethical perspectives, and form reasoned judgments.
- Understand the ethical theories and principles that underpin drug regulation.
- Evaluate the ethical implications of alternative pathways, such as Accelerated Approval and Compassionate Use, equipping students to assess potential benefits, risks, and societal consequences.
- Assess the ethical dimensions of drug pricing decisions and their impact on equity and accessibility, encouraging thoughtful reflection on the broader societal implications of pricing strategies.

**529-0041-00L Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics**

**Abstract**

Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

**Objective**

Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

**Content**

Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

**Lecture notes**

Lecture notes will be made available online.

**Prerequisites / notice**

Exercises are an integral part of the lecture.

Prerequisites:
- 529-0051-00 "Analytische Chemie I (3. Semester)"
- 529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity
Negotiation

551-0223-00L Immunology III W 4 credits 2V M. Kopf, S. B. Freigang, S. R. Leibundgut, F. Mair, A. Oxenius, C. Schneider, E. Slack, R. Spörri, further lecturers

Abstract
This course provides a detailed understanding of
- development of T and B cells
- the dynamics of a immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies
Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective
Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
- recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the “Danger” concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice
Immunology I and II recommended but not compulsory

551-0309-00L Concepts in Modern Genetics W 6 credits 4V Y. Barral, A. Hajnal, O. Voinnet, University lecturers

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIC348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree/courses/special-students-university-of-zurich.html

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

551-0317-00L Immunology I W 3 credits 2V M. Kopf, A. Oxenius

Autumn Semester 2024
Abstract Introduction into structural and functional aspects of the immune system.

Objective Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Mutually adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Competencies
<table>
<thead>
<tr>
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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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551-0512-00L Current Topics in Molecular and Cellular Neurobiology
551-0571-00L From DNA to Diversity: the Evolution of Multicellular Organisms (University of Zurich)
551-1153-00L Systems Biology of Metabolism
Objective
Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content
The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes
Script and original publications will be supplied during the course.

Prerequisites / notice
The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

551-1177-00L

Milestones in Immunology: From Milestones to Current Topics

W 4 credits 2S
B. Ludewig, N. Pikor, University lecturers

Abstract
Milestones in Immunology: on old concepts and modern experiments

Objective
The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Content
Milestones and current topics of innate immunity, antigen presenting, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

Lecture notes
Original and review articles will be distributed by the respective lecturer.

Literature
L iteraturunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app21 rencont Juliette de ETHZ/ch/course/view.php?id=15568

551-1303-00L

Current Research Topics in Cellular Biochemistry

W 4 credits 2S
T. Kleele, V. Korkhov, G. Neurohr, V. Panse, M. Peter, A. E. Smith, F. van Drogen

Abstract
During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

Objective
Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to evaluate, critically discuss and write about scientific articles in the research area of cellular biochemistry, and they will identify open testable research questions.

Content
Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with frontal presentations. Guided by a faculty expert, students develop domain knowledge of the research area associated with a primary paper, and alternate as discussion leaders to present the research topic. By the end of the semester, students will formulate their ideas about open testable research questions that extend from the published work.

Literature
The literature will be provided during the course.

Prerequisites / notice
The course will be taught in English.

551-1303-00L

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies

Social Competencies
Communication

Personal Competencies
Self-awareness and Self-reflection
Self-direction and Self-management

636-0017-00L

Computational Biology

W 6 credits 3G+2A
T. Vaughan, C. Magnus, T. Stadler

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
* epidemiology
* pathogen evolution
* macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

* Yang, Z. 2006. Computational Molecular Evolution.
* Drummond, A. & Bouck, R. 2015. Bayesian evolutionary analysis with BEAST.

**Prerequisites / notice**

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

**Competencies**

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**636-0108-00L Biological Engineering and Biotechnology**

**Abstract**

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objectives**

1. Insight into The Mammalian Cell Cycle. Cycling, The Balance Between Proliferation and Cancer - Implications For Biopharmaceutical Manufacturing.
2. The Licence To Kill. Apoptosis Regulatory Networks - Engineering of Survival Pathways To Increase Robustness of Production Cell Lines.

**Lecture notes**

Handout during the course.

**701-1703-00L Evolutionary Medicine for Infectious Diseases**

**Abstract**

This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat the disease effectively.

**Competencies**

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**Literature**

- Schmid Hempel 2011 Evolutionary Parasitology
- Stearns & Medzhitov 2016 Evolutionary Medicine

**Prerequisites / notice**

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

**752-3105-00L Physiology Guided Food Structure and Process Design**

**Abstract**

A sound understanding of physiological implications of food design will allow to shape new products, which feature health as well as environmental benefits and on the other side do not compromise on organoleptic qualities, formulation and manufacturing, and quality and safety. The course links the physiological driven requirements with food structure design and subsequent engineering steps.

**Objective**

The objective of this course is to highlight the link between human physiology, product sensory, nutritional functions, and engineering approaches to facilitate the design of food matrices reflecting the requirements for the beforementioned properties. To identify and manipulate these properties, the pathways that control the interaction of food structures and their physiological action will be introduced. Students are introduced to a skill set that will encompass basic digestion, sensory physiology knowledge, and food structures. Students will be exposed to the interplay along the gastrointestinal tract including taste, aroma, and texture perception, swallowing mechanics, and gastrointestinal digestion with an engineering or physical sciences angle.

**Content**

Chapter 1: Introduction - The need for physiology guided structure and process design in the context of personalized nutrition (Peter Fischer)
Chapter 2: Food Oral Processing; the impact of food oral breakdown on sensory perception (Marine Devezeaux de Lavergne)
Chapter 3: Chewing and swallowing across the lifespan, from infants to elderly (Marine Devezeaux de Lavergne)
Chapter 4: Perception physiology in humans and other species (Benot von der Weid)
Chapter 5: Biophysics of food digestion & how it can be exploited in the development of strategies for delivery (Timothy J. Wooster)
Chapter 6: Numerical and experimental modelling of the intestinal system (Peter Fischer)

**Lecture notes**

Lecture notes are available at Moodle
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
To be provided by the individual lecturers, at their discretion.

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-4009-00L Molecular Biology of Foodborne Pathogens

Abstract
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Objective
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content
The course will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Compcetencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

752-6101-00L Nutrition and Chronic Disease

Abstract
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
To be provided by the individual lecturers, at their discretion.

Prerequisites / notice
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

752-6105-00L Epidemiology and Prevention

Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health. The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Objective
The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

Compcetencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: fostered

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: fostered

736-0300-00L Essentials in Translational Science

Abstract
Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicines). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.
Objective
After completing this course, students will be able to understand:
Principles of translational science including medical device development, intellectual property, regulatory environment and project management
Students should be able to apply this knowledge in drug development programs in Pharma, Biotech or their own spin-off.

Content
What is translational science and what is it not Including:
How to identify need?
How to choose the appropriate research type and methodology
How to measure success?
How are medical devices developed?
How to handle IP in the development process?
How does the regulatory environment impact innovation?
How to manage complex development projects?
Positive and negative examples will be illustrated by distinguished guest speakers.

Literature
Principles of Biomedical Sciences and Industry
Translating Ideas into Treatments https://doi.org/10.1002/9783527824014

Prerequisites / notice
4x online input lecture followed by case preparation and symposium

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

376-0302-01L GCP Basic Course (Modules 1 and 2) O 1 credit 1G G. Senti, C. Fila, R. Grossmann

Abstract
The basic course in "Good Clinical Practice" (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

Objective
Students will get familiar with:
- Key Ethics documents
- (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

Content
Module 1:
Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

Elective Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>E. Konukoglu, E. Erdil, F. Yu</td>
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</table>

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.
Content

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

227-1037-00L Introduction to Neuroinformatics

Abstract

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Objective

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchancements and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

227-1047-00L Consciousness: From Philosophy to Neuroscience (University of Zurich)

Abstract

This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective features of consciousness are explored, and modern research into its neural substrate, particularly in the visual domain, is explained. Emphasis is placed on students developing their own thinking through a discussion-centered course structure.

Objective

The course's goal is to give an overview of the contemporary state of consciousness research, with emphasis on the contributions brought by modern cognitive neuroscience. We aim to clarify concepts, explain their philosophical and scientific backgrounds, and to present experimental protocols that shed light on a variety of consciousness related issues.

Content

The course includes discussions of scientific as well as philosophical articles. We review current schools of thought, models of consciousness, and proposals for the neural correlate of consciousness (NCC).

Lecture notes

None

Literature

We display articles pertaining to the issues we cover in the class on the course's webpage.

Prerequisites / notice

Since we are all experts on consciousness, we expect active participation and discussions!

263-5057-00L From Publication to the Doctor's Office

Abstract

This seminar course is designed to provide students with an opportunity to review and critically evaluate recent publications in medical field focusing on examples when CS method or bioinformatics/statistical technique has lead to an instrumentation, technique or drug approved for clinical practice use.

Objective

Throughout the course, students will read and analyze recent publications that demonstrate successful applications and sometimes failures in medicine. Promising research applications will also be discussed. The publications will cover a wide range of topics, including drug discovery, image analysis, prognostic models, and learning healthcare.
The course will be structured as half lecture content and half seminar content. Lectures will review state of the medical practice prior to the discovery, obstacles in moving the field forward, and the need for improvement. Lecture will be followed by the seminar part where students will take turns presenting the assigned publications and leading the discussions. Students’ presentations will focus on the main findings, and specific steps taken to translate the finding into clinical practice.

Publications will include examples of:
- specific CS/bioinformatics/statistics applications that has been brought to „bedside“ – has been approved by European Medicines Agency / Food and Drug Administration (USA) for clinical use or are widely used in medical research;
- examples of failures of how a discovery did not translate into an end product and why;
- current active research areas.

Covered topics will include some of the following:
- Drug discovery: Computer-aided drug discovery has become an integral part of the drug development process, enabling researchers to design and screen large libraries of molecules in silico (i.e., using computer simulations) before synthesizing and testing them in the lab. This has led to the discovery of new drug candidates for a wide range of diseases, including cancer, Alzheimer’s disease, and HIV/AIDS.
- Genomics: Advances in computational genomics have enabled researchers to analyze and interpret large-scale genomic data, including DNA sequencing data, to identify disease-causing mutations, genetic risk factors, and drug targets. Examples of the development of personalized medicine, where treatments are tailored to an individual’s genetic makeup. Examples when drug target identified by genetics has led to approved treatment.
- Imaging: Computer vision and image processing techniques have revolutionized medical imaging, enabling researchers to extract quantitative information from medical images that were previously inaccessible. This has led to the development of new diagnostic and prognostic tools for a wide range of diseases, including cancer, cardiovascular disease, and neurological disorders.
- Real-world data applications: emulation of clinical trials using electronic health records data.
- Large language models: Generating clinical trial protocols using large language models. Natural Language Processing for information extraction and interpretation.
- Learning healthcare systems: Advances in data analytics and information technology have enabled the development of learning healthcare systems, which use real-time data from electronic health records, medical devices, and other sources to improve patient outcomes and reduce healthcare costs. This has the potential to transform the way healthcare is delivered, making it more personalized, efficient, and effective.

In addition to the presentations, students will also be required to write critical reviews of the assigned publications throughout the course. The reviews will be evaluated based on the students’ ability to identify the strengths and weaknesses of the publications and to provide insightful and constructive feedback.

Prerequisites / notice
The course is intended for advanced undergraduate and graduate students with a background in computer science, bioinformatics, or a related field and interest in applying their skills to medical research.

This course assumes a working knowledge of R/Python and intermediate statistical analysis, including linear, logistic, survival regressions or ability and interest to learn them outside of the class.

Competencies

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<th>Method-specific Competencies</th>
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<td>Creativity</td>
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<td>Integrity and Work Ethics</td>
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<td>Problem solving</td>
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<td>Understanding</td>
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<td>Staying Calm</td>
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Microscopy Training SEM I - Introduction to SEM

327-2125-00L
W 2 credits 3P


For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP.html).

All applicants must additionally register on this form:
https://docs.google.com/forms/d/1Xw8BL_2yXTE9qXxW9C-c8mjkMVqdvX6sJEa--9CwDXkd0/edit

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications.

The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

- Create/select well-founded research hypothesis and study designs for a specific research topic
- Apply universal good clinical practice guidelines in future research projects
- Integrate well-documented data management and open science principles into future research projects

The course will cover the following topics:
- Introduction to different study designs and ethical requirements thereof in Switzerland
- Introduction to literature search and searching platforms
- How to collect and sort publications/ keep up to date on research topic

- How to critically evaluate papers
- How to pre-define study requirements to "future-proof" the research (hypothesis, sample size definition, pre-registration)
- Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metadata)
- FAIR principles and open science
- Design principles and free digital tools for graphical illustrations
- Effective summarizing of research output/topic in an abstract and pitch presentation

376-0816-00L  Applied Human Research Project Management  W  4 credits  3G  C. Lustenberger, M. Altermatt

Abstract
This course equips the students with several key principles such as good clinical practice, ethical study requirements, reproducible data management and effective oral, graphical, and written communication to design and manage good quality, ethically sound human research studies and represents a 101-toolkit of transferable research management skills/digital tools.

Objective
The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

- Create/select well-founded research hypothesis and study designs for a specific research topic
- Apply universal good clinical practice guidelines in future research projects
- Integrate well-documented data management and open science principles into future research projects

Content
The course will cover the following topics:
- Introduction to different study designs and ethical requirements thereof in Switzerland
- Introduction to literature search and searching platforms
- How to collect and sort publications/ keep up to date on research topic
- Inputs on critically evaluating papers
- How to pre-define study requirements to "future-proof" the research (hypothesis, sample size definition, pre-registration)
- Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metadata)
- FAIR principles and open science
- Design principles and free digital tools for graphical illustrations
- Effective summarizing of research output/topic in an abstract and pitch presentation

376-1177-00L  Human Factors I  W  3 credits  2V  M. Menozzi Jäckli, R. Huang

Abstract
Strategies of human-system-Interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people’s health, well-being, and satisfaction as well as the overall system performance.

Objective
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body sizes and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gabriel Salvandy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

376-1179-00L  Applications of Cybernetics in Ergonomics  W  1 credit  1U  M. Menozzi Jäckli, Y.-Y. Hedinger Huang, R. Huang

Abstract
Cybernetics systems have been studied and applied in various research fields, such as for applications in ergonomics. Topics discussed in this lecture (man-machine-Interaction, performance in multi-modal interactions, quantification in gesture principles for the use in product development, information processing) are deepened with exercises conducted at our labs.

Objective
To learn and practice cybernetics principles in interface designs and product development.

Content
- Fitts law applied in manipulation tasks
- Hick-Hyman law applied in design of the driver assistance systems - Vigilance applied in quality inspection
- Accommodation/vergence crosslink function
- Cross-link models in neurobiology- the ocular motor control system
- Human performance in optimization of production lines

Literature

376-1305-00L  Development of the Nervous System (University of Zurich)  W  3 credits  2V  University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO344

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmis/en/studies/application/deadline s.html

Abstract
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

Objective
On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills
- On successful completion of the module the student should be able to interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to the structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.
### 376-1305-01L Molecular Neurophysiology: From Molecules to Systems

**Enrollment for UZH students:**
Enrolment to this course unit only possible at ETH. Please mind the ETH enrolment deadlines for UZH students: [https://ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html](https://ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html)

**Objective**
Based on an understanding of molecular and cellular mechanisms, the aim is to provide a deepened insight into neurophysiological processes underlying complex brain functions – learning/memory, sleep, sensory.

**Content**
First, basic molecular and cellular mechanisms in nerve cells (excitability, neurotransmission, signal transduction, gene expression, synaptic plasticity) are introduced. Afterwards, their significance for selected neurophysiological processes (learning/memory, sleep, sensory) will be illuminated.

**Literature**
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle.

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies

**Literature**
- R. Fiore, W. von der Behrens, J. Winterer

**Prerequisites**
BIO142 Developmental Biology, BIO143 Neurobiology

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### 376-1309-00L Disorders of Social Cognition

**Enrolment possible with matriculation in Master HST**

- **Teaching Diploma or Teaching Certificate**

  This course unit can only be enrolled after successful participation in, or during enrolment in the course "Human Learning (EW I)".

  "!!! Teaching Diploma Sports: allocation of the ECTS only possible in the category "Educational Science" !!!"

**Abstract**
In this seminar, we consider how the human brain processes social information. The approach focuses on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies from atypical populations, whose pathologies are typified by dysfunction in social information processing, such as autism spectrum disorder and schizophrenia.

**Objective**
- To familiarise students with forms of social cognition in humans, as well as the neural systems that support social cognition.
- To critically evaluate theories and data relating to Social Cognition and Social Neuroscience.
- To relate how knowledge of typical brain function can inform our understanding of individuals who process social information differently, and vice versa.
- To develop effective scientific communication skills in oral and written formats.

**Content**
This seminar will consider how the human brain understands and organises social behaviour. The approach will focus on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies from atypical populations, whose pathologies are typified by dysfunction in social information processing. Examples of such pathologies include autism spectrum disorder, schizophrenia and attention deficit hyperactivity disorder. By examining healthy and atypical populations, this module will highlight how disorders of social cognition can inform the understanding of healthy brain function, as well as how understanding healthy brain function can inform disorders of social cognition.

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### 376-1311-00L Neuroscience Journal Club

**Abstract**
In this course students will learn about specialized topics and novel methods in neuroscience by critically reading and presenting scientific journal articles. The articles will focus on the "Neurobiology of Stress" topic and cover relevant preclinical neuroscience techniques (behavior, molecular, omics, brain imaging, circuit manipulations, genetic manipulations, electrophysiology, etc.).

**Objective**
By the end of the course, students will be able to critically review scientific papers published in top neuroscience journals. Specifically, students will be able to:
1. Identify strengths & weaknesses, useful techniques and take-home messages;
2. Prepare and structure slides to distil a complex scientific subject into a clear presentation;
3. Analyse and review the scientific techniques used in a peer-review research publication;
4. Perform a literature search within a scientific area;
5. Describe the scientific background for a new topic of research;
6. Summarize key points of a paper, from experimental details to big picture questions.

**Content**
This Neuroscience Journal Club is designed for Master and PhD students interested in neuroscience. Students will critically read and review a topical research article and present appropriate background, the article itself, and their critique of the work. The diversity of topics selected will make this an important learning opportunity for the presenters and attendees with regard to the latest techniques and approaches in neuroscience.

**Introductory Lectures:** In the first lecture, students will receive a general introduction to the topic “Neurobiology of Stress”, and learn the key skills to critically analyze and review a scientific paper. In the second lecture, the instructors will give a journal club presentation to provide an example of how a “journal club” should be structured. All other lectures are devoted to the journal club presentations given by the students. Depending on the number of enrolled students, groups of 1-3 students will select papers from a pre-selected list of high-impact publications. Each week, one group presents their paper, the presenters should show up 15-20 minutes before their scheduled presentation to set up their laptop.

**Active participation:** Each week, students that are not presenting are expected to read the article in its entirety in a critical manner and submit questions about the article online ahead of class, participation in class will be assessed.

**Workload:** 2h of class per week (attendance in person required), plus 8h for preparing your own journal club (1-2 per semester), plus 2h for reading other group’s paper and asking questions (1/week, 13 in total).

**Literature**
- Teaching Diploma or Teaching Certificate ---> This course unit can only be enrolled after successful participation in, or during enrolment in the course "Human Learning (EW I)"

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies

**Literature**
- J. Bohacek

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Prerequisites / notice

We recommend that students have a solid background in neuroscience.

Recommended ETH classes are:
Neuroanatomy & Neurophysiology (376-0007-00L) (or similar)
Anatomy and Physiology 1 & 2 (376-0151-00L + 376-0152-00L) (or similar)
Neural Systems for Sensory, Motor and Higher Brain Functions (376-1305-01V / Bio343) (or similar)
Translational Neuroscience (376-1307-00 V) (or similar)

<table>
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<th>Course Title</th>
<th>Credits</th>
<th>Lecturer(s)</th>
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<tr>
<td>376-1414-00L</td>
<td>Current Topics in Brain Research (HS)</td>
<td>1 credit</td>
<td>I. Mansuy, further lecturers</td>
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<tr>
<td>376-1504-00L</td>
<td>Physical Human Robot Interaction (pHRI)</td>
<td>4 credits</td>
<td>O. Lambercy, P. Wolf</td>
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</table>

Abstract

Different national and international scientific guests are invited to present and discuss their actual scientific results.

Objective

To exchange scientific knowledge and data and to promote communication and collaborations among researchers.

Content

Different scientific guests working in the field of molecular cognition, neurochemistry, neuromorphology and neurophysiology present their latest scientific results.

Lecture notes

no handout

Literature

no literature

Prerequisites / notice

Some of the seminars will be shared with the Institute of Neuroinformatics (INI) of UZH.

Abstract

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

Objective

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Content

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes

Will be distributed on Moodle before the lectures.
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

The students are expected to have basic control knowledge from previous classes.

http://www.relab.ethz.ch/education/courses/phri.html

**Literature**


**Prerequisites / notice**

The registration is limited to 26 students.

There are 4 credit points for this lecture.

The lecture will be held in English.

The students are expected to have basic control knowledge from previous classes.

http://www.relab.ethz.ch/education/courses/phri.html

**Competencies**

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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Self-direction and Self-management</td>
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**376-1651-00L Ethics of Life Sciences and Biotechnology**

**Abstract**

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

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The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Content

- Principles of biomedical ethics and how they relate pharmaceutical innovation
- Introduction to drug development, with a focus on the Swiss regulatory ecosystem
- Current trends and impediments to effective drug development, including the use of AI in drug discovery
- Translational medicine and its ethical implications
- Ethical Aspects of pre-clinical research, including animal replacement technologies like organoids and organ chips
- Ethical aspects of clinical research
- Special regulatory pathways: expanded access / compassionate use
- Special regulatory pathways: accelerated approval
- Drug development and public health. Emergency use of new drugs
- Drug pricing: introduction to its regulatory and ethical aspects

Objective

This course focuses on the concepts of classical and modern genetics and genomics. The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes

Scripts and additional material will be provided during the semester.

Y. Barral, A. Hajnial, O. Voinnet, to be announced

551-0309-00L  Concepts in Modern Genetics

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIC348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Abstract

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective

This course focuses on the concepts of classical and modern genetics and genomics.

Content

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes

Scripts and additional material will be provided during the semester.

Autumn Semester 2024
## 551-0317-00L Immunology I

**Abstract**
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**
Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Literature**
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

**Prerequisites / notice**
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

## 551-0319-00L Cellular Biochemistry (Part I)

**Abstract**
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

**Lecture notes**
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

**Literature**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

## 752-4009-00L Molecular Biology of Foodborne Pathogens

**Abstract**
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

**Objective**
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Recommendations will be given in the first lecture

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

The course introduces basic concepts of the interaction between nutrition and exercise performance.

To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise.

Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

Lecture slides and required handouts will be available on the ETH website (moodle).

Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

**Major in Rehabilitation and Inclusion**

**Compulsory Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0300-00L</td>
<td><strong>Essentials in Translational Science</strong></td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Goldhahn</td>
</tr>
</tbody>
</table>

**Abstract**

Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicines). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

**Objective**

After completing this course, students will be able to understand:

- Principles of translational science including medical device development, intellectual property, regulatory environment and project management
- Students should be able to apply this knowledge in drug development programs in Pharma, Biotech or their own spin-off.

**Content**

What is translational science and what is it not Including:

- How to identify need?
- How to choose the appropriate research type and methodology
- How to measure success?
- How are medical devices developed?
- How to handle IP in the development process?
- How does the regulatory environment impact innovation?
- How to manage complex development projects?
- Positive and negative examples will be illustrated by distinguished guest speakers.

**Literature**

Principles of Biomedical Sciences and Industry

Translating Ideas into Treatments

https://doi.org/10.1002/9783527824014

4x online input lecture followed by case preparation and symposium

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>376-0302-01L</td>
<td><strong>GCP Basic Course (Modules 1 and 2)</strong></td>
<td>O</td>
<td>1 credit</td>
<td>1G</td>
<td>G. Senti, C. Fila, R. Grossmann</td>
</tr>
</tbody>
</table>
Abstract

The basic course in "Good Clinical Practice" (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

Objective

Students will get familiar with:
- Key Ethics documents
- (International) Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

Content

Module 1:
Research and Research Ethics, Guidelines, (international) Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

Electives

Rehabilitation Technology

Students majoring in Rehabilitation and Inclusion: At least 3 CP of the courses in this focus area must be selected.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-3110-00L</td>
<td>Human Computer Interaction</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>C. Holz</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As well as understand the basic notions of Computational Design in a HCI context.</td>
<td></td>
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<tr>
<td>Content</td>
<td>The course will introduce students to several methods of analysing the user experience, showing how these can be used at different stages of system development from requirements analysis through to usability testing. Students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.</td>
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</tbody>
</table>

| 363-0790-00L | Technology Entrepreneurship               | W    | 2    | 2V            | F. Hacklin      |
| Abstract    | Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding. This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture. |      |      |               |                 |
| Objective   | This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases. |      |      |               |                 |
| Content     | Weekly sessions - recorded. 10+ sessions carried out by guest lecturers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...). Final session: multiple choice semester assignment (100% of grade). Typical lecture format (2h): 15': Introduction 60': Guest testimonial 15': Discussion related to topic (in groups) 10': Plenary discussion 20': Q&A with (guest) lecturer |      |      |               |                 |
| Competencies| Subject-specific Competencies Concepts and Theories | assessed |
|            | Method-specific Competencies Analytical Competencies | assessed |
|            | Problem-solving | assessed |
|            | Social Competencies Communication | fostered |
|            | Cooperation and Teamwork | fostered |
|            | Sensitivity to Diversity | fostered |
| Personal Competencies Critical Thinking | assessed |

| 376-1176-00L | Wearable and Mobile Technologies of the Future - Focus on Sports and Health | W    | 4    | 3G            | C. Menon, C. Ahmadizadeh, C. Chesteau |
| Abstract    | This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications. |      |      |               |                 |
Objective 1: 
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2: 
Acquire skills to design novel non-invasive technologies for sport and health.

Content
The course consists of two modules.

Module 1: Movement.
This module provides the scientific background needed to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies.

Module 2: Cardiac.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies and the latest data analysis techniques to monitor the cardiac cycle for assisting individuals in sport activities or monitoring their health conditions.

Prerequisites / notice
- Students should be proficient in programming (any language).
- Note: assignments will be in MATLAB. Students are expected to learn MATLAB on their own if not experienced with this programming language.
- Course prerequisites:
  - For Biomedical Engineering Master’s: none
  - For ITET Master’s: none
  - For D-MAVT Master’s and PhD students:
    - If BSc in electrical/mechanical engineering or computer science: none
    - If any other BSc program: 376-0022-00L (Imaging and Computing in Medicine) or 376-1983-00L (Foundations of Data Science)

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

Abstract
Rehabilitation Enng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

Content
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces
Literature

Introductory Books:


Selected Journal Articles and Web Links:


Prerequisites / notice

Target Group:
Students of higher semesters and PhD students of:
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich

Students of other departments, faculties, courses are also welcome.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed

Social Competencies
- Communication fostered
- Leadership and Responsibility fostered

Personal Competencies
- Creative Thinking fostered
- Critical Thinking assessed
- Integrity and Work Ethics fostered

376-1229-00L Artificial Intelligence in Rehabilitation and Healthcare W 3 credits D. F. Paez Granados

Abstract

Students will delve into AI fundamentals (e.g., regression, classification, and deep neural networks) and their role in patient monitoring & personalized rehab. Collaborative projects offered by MedTech companies provide hands-on experience in developing and evaluating AI-driven solutions. This course will emphasise AI's explainability and ethical dimensions fostering its critical analysis.
Objective
1. Evaluate the effectiveness of AI tools and algorithms in the context of rehabilitation and healthcare, and suggest modifications or improvements as needed.
2. Understand the ethical and legal considerations surrounding the use of AI in rehabilitation and healthcare and apply this knowledge to ensure patient privacy and data security.
3. Identify potential limitations and risks of using AI in rehabilitation and healthcare and propose strategies to mitigate these challenges.
4. Collaborate effectively with other students on group projects that involve developing and implementing AI-based rehabilitation and healthcare solutions.

Content
In the class ‘Artificial Intelligence (AI) in Rehabilitation and Healthcare’, we will explore the integration of advanced technology in the field of rehabilitation. The class consists of both theoretical and practical components. In the theoretical part, students are introduced to the fundamental concepts of artificial intelligence, including regressions and classification in machine learning, deep neural networks, and large language models. They will explore the applications of AI in rehabilitation and healthcare, including patient monitoring, personalized treatment plans, and predictive analytics.

In the practical component, each student will work with one of the clinics or technology companies to identify real-world problems and gain hands-on experience in developing AI in rehabilitation and healthcare. The practical work will be done in the course room with student assistants and experts from the companies. They will use Python as main language on their own laptops with ready to use Jupiter notebooks that could have access to our lab’s server if needed for computational resources. They will directly start using programming languages and tools to build models, analyze data, and create algorithms that can be used to improve patient outcomes.

Throughout the class, students are encouraged to think critically about the ethical implications of using AI in rehabilitation. They examine the potential benefits and risks of using advanced technology in patient care and explore ways to mitigate potential negative outcomes.

Prerequisites / notice
Required classes:
- 401-0643-00L Statistik I
- 401-0643-13L Statistik II
- 376-1983-00L Foundations of Data Science

Recommended courses:
- 252-0842-00L Programmieren und Problemlösen

Rehabilitation Medicine
Students majoring in Rehabilitation and Inclusion: At least 3 CP of the courses in this focus area must be selected.

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<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>376-0225-00L</td>
<td>Critical Appraisal of Evidence for Exercise in Health and Disease</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>E. Giannouli, E. de Bruin, R. Knols</td>
</tr>
</tbody>
</table>

Abstract
This course provides a holistic, clinical view on the in- and outpatient rehabilitation process of neurological diseases with a special focus on movement deficits. Pharmacological, training and medical device-supported interventions with their potential and limitations are discussed from a clinical perspective along the patient journey – covering the different phases of inpatient rehab.

Literature

Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered

- Method-specific Competencies
  - Analytical Competencies: fostered
  - Decision-making: fostered
  - Problem-solving: fostered

- Personal Competencies
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered

376-1222-00L Motor Neurorehabilitation

Abstract
This course provides a holistic, clinical view on the in- and outpatient rehabilitation process of neurological diseases with a special focus on movement deficits. Pharmacological, training and medical device-supported interventions with their potential and limitations are discussed from a clinical perspective along the patient journey – covering the different phases of inpatient rehab.
Students are expected to:
- develop a holistic, clinical view on the different phases of neurorehabilitation
- understand how motor deficits develop, which pathology to the central nervous system causes which type of deficit and how each deficit can be treated
- understand different patient journeys in dependence on the underlying deficits and individual personal and environmental factors
- discuss and interpret the impact of clinical trial findings for rehabilitation

Symptomatology: Motor deficits in clinical practice
- Disorders leading to motor deficits 1: Stroke and brain trauma
- Disorders leading to motor deficits 2: Spinal cord injury
- Disorders leading to motor deficits 3: Peripheral nerve injury and muscle diseases
- Disorders leading to motor deficits 4: Movement disorders
- Brain plasticity in the motor system
- Training interventions 1: Strength and endurance
- Training interventions 2: Stance and gait
- Training interventions 3: Arm and fine motor control
- Pharmacological support for recovery
- Brain stimulation to support motor recovery
- Movement and cognition & vision
- Motor learning based training interventions
- Clinical importance of motivation for movement recovery

Objective
Students will
- get to know the different rehabilitation types, their specific challenges and discuss potential solutions
- comprehend future trends in rehabilitation and identify required actions
- gain insight into rehabilitation clinics and hands-on experience

Content
- Introduction into rehabilitation landscape
- Introduction into physical medicine
- Rehabilitation types
  - Geriatric Rehabilitation
  - Internistic and Oncological Rehabilitation
  - Cardiovascular Rehabilitation
  - Musculoskeletal Rehabilitation
  - Neurological Rehabilitation
  - Pediatric Rehabilitation
  - Paraplegiologic Rehabilitation
  - Psychosomatic Rehabilitation
  - Pulmonal Rehabilitation
- Challenges in rehabilitation from a clinical perspective
- Future trends in rehabilitation

Prerequisites / notice
Basic knowledge on anatomy and physiology of the central nervous system required.

Objective
Students majoring in Rehabilitation and Inclusion: At least 3 CP of the courses in this focus area must be selected.

Content
This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

Prerequisites / notice
A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.
The course will cover the following topics:

- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technology: computer-assisted therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prosthesis, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Parasports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention

## Competencies

### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

### Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Sensitivity to Diversity

### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

## Content

### 376-1221-00L

**Economic and Regulatory Principles of Rehabilitation**

- **W** 1 credit
- **IV** 1 credit
- **S. Altmann**

**Abstract**

Medical health care in Switzerland is diverse and includes somatic and psychological prevention, treatment, rehabilitation and social and professional reintegration. The lecture deals with the economic and regulatory principles of medical rehabilitation and reintegration. It introduces these areas of healthcare and places them in the context of the entire care chain.

**Objective**

The students know the economic and regulatory framework conditions of medical rehabilitation and occupational and social reintegration in the Swiss health care system.

The students are familiar with the market participants and their strategies and intentions.

The students are aware of the importance of associations which, as representatives of the sector, express their views on quality and tariffs and deal with political issues. Interfaces, dependencies and cooperations between the individual actors are known.

The students will analyze the strengths and weaknesses of the Swiss health care system, also in comparison with foreign models, and will develop solutions to overcome the current problems with a focus on rehabilitation and reintegration.

The market participants such as service providers, financiers, suppliers or authorities are introduced and the mutual dependencies are shown.

The market mechanisms are presented and the range of services, financial flows, tariff situation, consolidations and regulation are discussed.

Special attention is paid to megatrends such as cost pressure, shortage of skilled workers, ambulantization, digitalization or technologization and the influence of demographic change.

### 376-1661-00L

**Ethics of Life Sciences and Biotechnology**

- **W** 3 credits
- **2V** 2 credits
- **A. Blasimme, E. Vayena**

**Abstract**

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

**Objective**

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

**Content**

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.
**376-1722-00L Spinal Cord Injury and Exercise**

**Prerequisites:** Anatomy and Physiology.

**Objective:** Knowledge of the pathophysiology and the concomitant complications of a spinal cord injury and the consequences for physical exercise and trainability during rehabilitation as well as in recreational and elite sport.

**Content:** The following issues will be discussed: Epidemiology and etiology of spinal cord injury; complications and consequences of spinal cord injury; trainability/exercise physiology and spinal cord injury; history and organisation of wheelchair sports; elite sport and spinal cord injury

**Literature:**
- H.G. Koch, V. Geng. Querschnittlähmung verständlich erklärt (Band 1 und Band 2). Selbstverlag Manfred-Sauer-Stiftung und Schweizer Paraplegiker-Vereinigung. ISBN 978-3-00-069888-0 (Band 1) und 978-3-00-069889-7 (Band 2)

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**752-6151-00L Public Health Concepts**

**Prerequisites:**

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: fostered
  - Media and Digital Technologies: fostered
  - Problem-solving: assessed

- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: fostered
  - Leadership and Responsibility: fostered
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: fostered

- **Personal Competencies**
  - Adaptability and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered
Abstract
The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

Objective
At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

Content
Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition).

Lecture notes
Handouts are provided to students in the classroom.

Competencies
Subject-specific Competencies
Concepts and Theories
Method-specific Competencies
Analytical Competencies
Decision-making

Practical Training
Practical Training only for majors mentioned below:
- Human Movement Science and Sport
- Medical Technology
- Molecular Health Sciences
- Neurosciences
- Rehabilitation and Inclusion

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<tr>
<th>Number</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>376-2110-00L</td>
<td>Practical Training 12 Weeks (Job or Research Oriented)</td>
<td>W</td>
<td>15 credits</td>
<td></td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school).</td>
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<tr>
<td>Objective</td>
<td>Students should exercise scientific working and/or get realistic insights into future jobs.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This version of internships lasts for at least 12 weeks full time equivalent.</td>
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<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>376-2111-00L</td>
<td>Practical Training 8 Weeks (Job or Research Oriented)</td>
<td>W</td>
<td>10 credits</td>
<td></td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school).</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Students should exercise scientific working and/or get realistic insights into future jobs.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>This version of internships lasts for at least 8 weeks full time equivalent.</td>
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</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-2112-00L</td>
<td>Practical Training 4 Weeks (Job or Research Oriented)</td>
<td>W</td>
<td>5 credits</td>
<td></td>
<td>Supervisors</td>
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<tr>
<td>Abstract</td>
<td>Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school).</td>
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<tr>
<td>Objective</td>
<td>Students should exercise scientific working and/or get realistic insights into future jobs.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This version of internships lasts for at least 4 weeks full time equivalent.</td>
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</table>

Science in Perspective
see Science in Perspective: Language Courses ETH/UZH
see Science in Perspective: Type A: Enhancement of Reflection Capability
Recommended Science in Perspective (Type B) for D-HEST

Research Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-2100-00L</td>
<td>Research Internship</td>
<td>O</td>
<td>15 credits</td>
<td></td>
<td>Supervisors</td>
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<tr>
<td>Abstract</td>
<td>12-week internship intended for exercising (independent) scientific working.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students shall exercise scientific working as preparation for their master thesis.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The Research Internship lasts for at least 12 weeks full time equivalent. It can be combined with the Master Thesis.</td>
<td></td>
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</table>

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-2000-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>71D</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Only students fulfilling the following criteria can start with their master thesis: a. successful completion of the bachelor programme; b. fulfillment of any additional requirements necessary to gain admission to the master programme.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The students shall demonstrate their ability to carry out a structured, scientific piece of work independently.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The Master Thesis can only be started after the Bachelor Degree was obtained and/or master admission requirements have been fulfilled.</td>
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</table>

Course Units for Additional Admission Requirements

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1321 of 2667
### Mathematics I & II

#### A. Vaterlaus

**Concepts and Theories**

Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity.

**Title**

**Subject-specific Competencies**

Mathematics I covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems, notably through

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical

**1. Linear Algebra and Complex Numbers:**

Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics

1. Linear Algebra and Complex Numbers:

   - systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms
   - for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

2. Single-Variable Calculus:

   - review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration
   - methods, improper integrals.

3. Ordinary Differential Equations:

   - separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of
   - linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

4. Multivariable Calculus:

   - functions of several variables, partial differentiation, curves and surfaces in space, scalar and vector fields, gradient, curl and divergence.

5. Multivariable Integral Calculus:

   - multiple integrals, line and surface integrals, work and flow, Green, Gauss and Stokes theorems, applications.

6. Introduction to Partial Differential Equations:

   - separation of variables, heat equation, wave equation, Laplace equation.

**Lecture notes**

See literature

- Bretscher, O.: Linear Algebra with Applications, Pearson Prentice Hall.

**Prerequisites / notice**

Prerequisites:

- familiarity with the basic notions from Calculus, in particular those of function, derivative and integral.

Schedule and location of the assistance hours (Mathe-Lab) may be found on the Moodle webpages for the parallel courses in German:

- 401-0251-00L Mathematik I in the Fall semester and
- 401-0252-00L Mathematik II in the Spring semester.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
</tr>
</tbody>
</table>

**Number** 406-0253-AAL

**Title** Mathematics I & II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

- Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

- Mathematics I covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems, notably through
- linear algebra and calculus, with an emphasis on ordinary differential equations.
- The main focus of Mathematics II is multivariable calculus.

**Objective**

- Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling
- cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the
- help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the
- most important tool for modelling and are therefore a main focus of these courses.

- They analyse and describe human movement according to the laws of mechanics.
- Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics
- such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of
- view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering
- the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

**Number** 376-0203-AAL

**Title** Movement and Sport Biomechanics

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

- Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course!

**Abstract**

- Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity
- with injury, discomfort, prevention and rehabilitation.

**Objective**

- "Students are able to describe the human body as a mechanical system.
- They analyse and describe human movements according to the laws of mechanics."

**Content**

- Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics
- such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of
- view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering
- the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

**Number** 406-0062-AAL

**Title** Physics I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

- Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

- Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and
- hydrodynamics, periodic motion and mechanical waves.

**Objective**

- Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical
- models, and to solve the latter.
- The student should acquire an overview over the basic concepts in mechanics.

**Content**

- Chapters:
  1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-
  6).
### Literature

Friedhelm Kuypers  
*Physik für Ingenieure und Naturwissenschaftler*  
Band 1: Mechanik und Thermodynamik  
Wiley-VCH Verlag, 2002  
4th edition 2022

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Assessed</th>
<th>Techniques and Technologies</th>
<th>Fostered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td></td>
<td></td>
<td>Analytical Competencies</td>
<td>Fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td></td>
<td></td>
<td>Problem-solving</td>
<td>Assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Self-direction and Self-management</td>
<td>Fostered</td>
</tr>
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</table>

### Health Sciences and Technology Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Lecture</td>
</tr>
<tr>
<td>G</td>
<td>Lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>Exercise</td>
</tr>
<tr>
<td>S</td>
<td>Seminar</td>
</tr>
<tr>
<td>K</td>
<td>Colloquium</td>
</tr>
<tr>
<td>P</td>
<td>Practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>Independent project</td>
</tr>
<tr>
<td>D</td>
<td>Diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>Revision course / private study</td>
</tr>
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</table>

### ECTS

- European Credit Transfer and Accumulation System  

Special students and auditors need special permission from the lecturers.
High-Energy Physics (Joint Master with IP Paris)

Core Subjects

Core Courses in Theoretical Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0843-00L</td>
<td>Quantum Field Theory I</td>
<td>W</td>
<td>10</td>
<td>4V+2U</td>
<td>L. Senatore</td>
</tr>
</tbody>
</table>

Abstract
This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity.
Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

Objective
The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

Lecture notes
Will be provided as the course progresses

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Core Courses in Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0891-00L</td>
<td>Phenomenology of Particle Physics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>P. Crivelli, A. de Cosa</td>
</tr>
</tbody>
</table>

Abstract
The course focuses on the connection between particle physics theory and experimental results to provide a comprehensive modern view of the Standard Model. The covered topics are quantum electrodynamics (QED) and quantum chromodynamics (QCD).

Objective
The students will deepen the knowledge on particle physics acquired during their bachelor studies. They will be able to apply the basics of relativistic quantum field theory (QFT) to derive the Feynman rules and to apply those to compute QED and QCD processes. They will be able to explain and discuss the connection between theory and experiments.

Content
Topics to be covered in Phenomenology of Particle Physics I:
- Relativistic kinematics
- Decay rates and cross sections
- Quantisation of Klein-Gordon (boson) and Dirac (fermion)’s fields
- From the S-matrix to the Feynman rules of QED
- Scattering processes in QED/QCD and running of alpha and alpha_s
- Experimental tests of QED and QCD

Literature
As described in the entity: Lernmaterialien

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assisted

Method-specific Competencies
- Analytical Competencies assisted
- Problem-solving aided

Social Competencies
- Communication aided

Personal Competencies
- Creative Thinking fostered

Electives

Optional Subjects in Physics

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0220-MSL</td>
<td>Extended Research Project</td>
<td>W</td>
<td>4</td>
<td>8A</td>
<td>Supervisors</td>
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</tbody>
</table>

This course unit can only be booked together with a research project (402-0218-MS). This extension is not available for the options Proseminars, Particle Physics at PSI, Medical Physics and Experimental Foundations of Particle Physics. The extension is only possible with the agreement of the supervising professor. The extension must be booked at the same time as the research project.
Abstract

Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

Objective

The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.

Content

- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

Prerequisites / notice

The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.
Acquire an in-depth understanding and overview of the essential elements of experimental methods in particle and astroparticle physics.

### 402-0715-00L Low Energy Particle Physics

**W 6 credits 2V+1U**

**A. S. Antognini, D. Ries**

**Abstract**
Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate on flagship experiments which have significantly improved our understanding of particle physics today, concentrating mainly on precision experiments with neutrons, muons and exotic atoms.

**Objective**
You will be able to present and discuss:
- the principle of the experiments
- the underlying technique and methods
- the context and the impact of these experiments on particle physics

**Content**
Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one directly searches for new particles at energies up to the TeV range. In a complementary way, low energy particle physics indirectly probes the existence of such particles and provides constraints for "new physics", making use of high precision and high intensities.

Besides the sensitivity to effects related with new physics (e.g. lepton flavor violation, symmetry violations, CPT tests, search for electric dipole moments, new low mass exchange bosons etc.), low energy physics provides the best test of QED (electron g-2), the best tests of bound-state QED (atomic physics and exotic atoms), precise determinations of fundamental constants, information about the CKM matrix, precise information on the weak and strong force even in the non-perturbative regime etc.

Starting from a general introduction on high intensity/high precision particle physics and the main characteristics of muons and neutrons and their production, we will then focus on the discussion of fundamental problems and ground-breaking experiments:
- search for rare decays and charged lepton flavor violation
- electric dipole moments and CP violation
- spectroscopy of exotic atoms and symmetries of the standard model
- what atomic physics can do for particle physics and vice versa
- neutron decay and primordial nucleosynthesis
- atomic clock
- Penning traps
- Ramsey spectroscopy
- Spitzer manipulation
- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling....

**Literature**
- Golub, Richardson & Lamoreaux: "Ultra-Cold Neutrons"
- Rauch & Werner: "Neutron Interferometry"
- Carlile & Willis: "Experimental Neutron Scattering"
- Byrne: "Neutrons, Nuclei and Matter"
- Klappdor-Kleingrothaus: "Non Accelerator Particle Physics"

**Prerequisites**
Einführung in die Kern- und Teilchenphysik / Introduction to Nuclear- and Particle-Physics

### 402-0725-00L Experimental Methods and Instruments of Particle Physics

**W 6 credits 3V+1U**

**M. Backhaus, D. Sgalaberna**

**Abstract**

**Objective**
Acquire an in-depth understanding and overview of the essential elements of experimental methods in particle and astroparticle physics.

**Content**
1. Examples of modern experiments
2. Introduction to particle sources and accelerators
4. Detailed analysis of non-electronic, noble element, solid state, scintillator-based and Cherenkov particle detectors
5. Experimental techniques for particle tracking, calorimetry and identification
6. Monte Carlo simulations, trigger and data acquisition system readout

**Lecture notes**
Slides are handed out regularly

**Literature**
- H. Kolanoski and N. Wermes, "Particle Detectors: Fundamentals and Applications".
- C. Grupen and B. Schwartz, "Particle Detectors".
- G.F. Knoll, "Radiation Detection and Measurements".

### 402-0767-00L Neutrino Physics

**W 6 credits 2V+1U**

**A. Rubbia, D. Sgalaberna**

**Abstract**
Theoretical basis and selected experiments to determine the properties of neutrinos and their interactions (mass, spin, helicity, chirality, oscillations, charge-parity violation, interactions with leptons and quarks) and implications on physics beyond the Standard Model of elementary particles as well as on Cosmology.
Criticalize analyze and elaborate the neutrino production and detection techniques. Derive the theory of neutrino scattering and analyze its implications in neutrino experiments. Analyze the phenomenology of neutrino oscillations and its implication on the physics Beyond the Standard Model of particles. Derive the main concepts of the theory of neutrino masses within and beyond the Standard Model of particles and analyze the experimental techniques related to the measurement of the neutrino masses. Describe the role of neutrinos in Cosmology and make connections with current and future neutrino experiments. Review the experimental configurations and analyze the challenges in searches for leptonic Charge-Parity symmetry violation and the measurement of the neutrino mass hierarchy.

Subject-specific Competencies

- Particle Accelerator Physics and Modeling I
- Quantum Simulations of Gauge Theories
- General Relativity

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Literature

- D.O. Caldwell, Current Aspects of Neutrino Physics, Springer.

K. Zuber, “Neutrino Physics” CRC Press 2020

Competencies

- Subject-specific Competencies
- Concepts and Theories
- assessed
- Techniques and Technologies
- assessed
- Method-specific Competencies
- Analytical Competencies
- assessed
- Problem-solving
- assessed
- Personal Competencies
- Creative Thinking
- fostered
- Critical Thinking
- assessed

402-0777-00L Particle Accelerator Physics and Modeling I

Objective

- Does not take place this semester.
- You obtain a theoretical understanding of the building blocks of particle accelerators. Modern numerical analysis tools allow you to model state-of-the-art particle accelerators. We will develop a Julia simulation tool (JuliAccel.jl) that reflects the theory from the lecture.

Content

- Recrupe Relativistic Classical Mechanics and Electrodynamics
- Building Blocks of Particle Accelerators
- Lie Algebraic Structure of Classical Mechanics and Application to Particle Accelerators
- Symplectic Maps & Analysis of Maps
- Symplectic Particle Tracking
- Collective Effects
- Linear & Circular Accelerators

Lecture notes

- Lecture notes
- This lecture is also suited for PhD. students

Prerequisites / notice

- Physics, Computational Science (RW) at MSc. Level
- In exceptional cases students at BSc level can attend.

Competencies

- Subject-specific Competencies
- Concepts and Theories
- assessed

402-0836-16L Quantum Simulations of Gauge Theories

Objective

- After acquiring the foundations on lattice formulation of gauge theories, and challenges of conventional Monte Carlo simulation approaches, the students will learn about different strategies for quantum simulation of gauge theories and their implementation on digital and analog quantum devices.

Content

- 1. Background and Motivation
- 1.1 From Quantum Field Theories to Lattice field theories;
- 1.2 Lattice Gauge Theories - Lagrangian formulation, gauge symmetries, observables;
- 1.3 Monte Carlo simulations, sign problems, and complex actions.
- 2. Road-map for Quantum Simulation of Gauge Theories
- 2.1 Hamiltonian formulation, Wilson’s formulation, and the infinite Hilbert spaces;
- 2.2 Finite Hilbert spaces: Z(N) gauge theories. Dualizing the Ising model and relation with the toric code;
- 2.3 Finite Hilbert spaces: Quantum link models for Abelian gauge theories;
- 2.4 Finite Hilbert spaces: Quantum link models for non-Abelian gauge theories;
- 2.5 Exploring the physics of gauge theories - phases, dynamics, and thermalization;
- 2.6 Exploring methods for gauge theories - exact diagonalization, tensor networks, Monte Carlo.
- 3. Quantum Simulation Approaches and Platforms
- 3.1 Digital vs. analog quantum simulations;
- 3.2 Proposals for simulations of gauge theories, realization, and perspectives.

Literature

- Quantum chromodynamics on the lattice (Christof Gattringer, Christian B. Lang, Series Title: Lecture Notes in Physics. DOI: https://doi.org/10.1007/978-3-642-01850-3).

402-0830-00L General Relativity

Objective

- Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.
Introduction to Effective Field Theories

Will be provided at the Moodle site for the course.

1) G. Dissertori, I. Knowles, M. Schmelling: "Quantum Chromodynamics: High Energy Experiments and Theory" (The International Series

Students will be introduced to the theory of Quantum Electrodynamics, and the use of Feynman diagrams to arrive at theoretical

Introduction to Quantum Electrodynamics

Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and

Content

Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable

Literature

Suggested textbooks:

C. Misner, K. Thorne and J. Wheeler: Gravitation
S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
S. Weinberg - Gravitation and Cosmology

402-0845-61L Effective Field Theories for Particle Physics W 6 credits 2V+1U A. Signer

Abstract

The focus of the course is on Effective Field Theories (EFTs) and their interplay with dispersion theory. These topics will be discussed both in general terms and with specific phenomenological applications in the context of physics beyond the Standard Model, effective description of the weak interaction, as well as the description of non-perturbative strong interaction at low energies.

Objective

This course covers the basic concepts of effective field theories (EFTs) and dispersion theory. We will start by introducing the core concept of constructing EFTs and apply them to the low-energy description of the weak interaction and the effective description of heavy physics beyond the Standard Model.

In the next part of the course, we will discuss Chiral Perturbation Theory (ChPT), the low-energy effective theory of Quantum Chromodynamics (QCD). We will briefly discuss the application of this concept to describe a class of theories beyond the SM in which the SM Higgs arises as a composite state of a new confining sector.

The second focus of the course is on dispersion theory and its interplay with EFTs. We will discuss how to make use of the constraints from unitarity of the S-matrix and analyticity of scattering amplitudes, in order to extend the range of validity of the theoretical description compared to pure EFT methods. We will also discuss how to obtain constraints on EFT parameters from unitarity and analyticity. We will discuss the application of these methods both in the context of low-energy strong interaction and physics beyond the Standard Model.

Content

- Introductory to Effective Field Theories
- Decoupling and matching
- Renormalization group resummation
- The Standard Model Effective Field Theory (SMEFT)
- Chiral Lagrangians
- Unitarity of the S-matrix
- Analyticity and dispersion relations

Prerequisites / notice

QFT-I (mandatory) and QFT-II (highly recommended)

402-0851-00L QCD: Theory and Experiment W 3 credits 3G A. Gehrmann-De Ridder, R. Wallny

Abstract

Does not take place this semester.

Special Students UZH must book the module PHYS561 directly at UZH.

Objective

Knowledge acquired on basics of perturbative QCD, both of theoretical and experimental nature. Ability to perform simple calculations of perturbative QCD, as well as to understand modern publications on theoretical and experimental aspects of perturbative QCD.

Content

QCD Lagrangian and Feynman Rules
QCD running coupling
Parton model
DGLAP
Basic processes
Experimental tests at lepton and hadron colliders
Measurements of the strong coupling constant

Literature

2) R. K. Ellis, W. J. Stirling, B. R. Webber : "QCD and Collider Physics" (Cambridge Monographs on Particle Physics, Nuclear Physics & Cosmology)

Prerequisites / notice

Will be given as block course, language: English.
For students of both ETH and University of Zurich.

402-0870-00L Introduction to Quantum Electrodynamics W 6 credits 2V+1U A. Lazopoulos

Abstract

This course provides a pedagogical introduction to Quantum Electrodynamics.

Objective

Students will be introduced to the theory of Quantum Electrodynamics, and the use of Feynman diagrams to arrive at theoretical predictions for phenomena related to the interaction of light and matter. The course is designed to complement Quantum Field Theory I for those students with a special interest in theoretical elementary particle physics.

Content

The course will cover:
- an introduction to QED as the quantum theory of interactions of light and matter.
- Feynman rules for QED
- Amplitudes and cross sections for simple processes in QED
- Gauge invariance and the Ward identity
- Ultraviolet singularities and Renormalization
- Infrared singularities and their cancelation
- The Uehling potential and the Lamb shift
- Anomalous magnetic moments

Lecture notes

Will be provided at the Moodle site for the course.

Literature

Will be provided at the Moodle site for the course.

Competencies

Subject-specific Competencies: Concepts and Theories, assessed
Techniques and Technologies, assessed

Method-specific Competencies: Analytical Competencies, assessed
Problem-solving, assessed

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1328 of 2667
402-0883-63L  Symmetries in Physics  W  6 credits  3G  G. M. Graf

Abstract
The course gives an introduction to symmetry groups in physics. It explains the relevant mathematical background (finite groups, Lie groups and algebras as well as their representations), and illustrates their important role across modern physics.

Objective
The aim of the course is to give a self-contained introduction into finite group theory as well as Lie theory from a physicists point of view. Abstract mathematical constructions will be illustrated with examples from physics.

Content
Finite group theory, including representation theory and character methods; applications to crystallography and solid state physics. The symmetric group and the structure of its representations; applications to identical particles. Clifford algebras; application to relativistic wave equations. Simple Lie algebras and their finite-dimensional representations. Description of representations of SU(N) in terms of Young diagrams; applications in particle physics.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

402-0886-00L  QCD and Scattering Amplitudes  W  6 credits  2V+1U  A. Gehrmann-De Ridder

Abstract
Special Students UZH must book the module PHYS64 directly at UZH.

Objective
The course presents the quantum field theory of the strong interaction (quantum chromodynamics, QCD) and discusses its applications to particle physics observables.

Content
Content:
- Review of non-Abelian gauge theories
- Renormalization of QCD and running coupling constant
- Jet observables in e^+e^- annihilation
- QCD at lepton-proton colliders
- Multiparticle production
- Spinor-helicity formalism
- Perturbation theory techniques: loops and phase space

Prerequisites / notice
The course assumes prior knowledge of the content of the quantum field theory 1+2 lectures.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered

402-0897-00L  Introduction to String Theory  W  6 credits  2V+1U  J. Brödel

Abstract
String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

Objective
Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

Content
- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- critical dimension and no-ghost theorem
- D-branes, T-duality
- two-dimensional conformal field theories

Literature
M.B. Green, J.H. Schwarz, E. Witten, Superstring Theory I, CUP (1987).

Prerequisites / notice
Recommended: Quantum Field Theory I (in parallel)

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Optional Subjects in Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3531-00L</td>
<td>Differential Geometry I</td>
<td>W</td>
<td>9</td>
<td>4V+1U</td>
<td>U. Lang</td>
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</table>

At most one of the three course units (Bachelor Core Courses) 401-3461-00L Functional Analysis I 401-3531-00L Differential Geometry I 401-3601-00L Probability Theory can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract
Introduction to differential manifolds and differential geometry.

Objective
Learn to compute, describe, prove, and solve problems in the language of differential geometry.
Content
Submanifolds of $\mathbb{R}^n$, immersions, submersions, and embeddings, Sard's Theorem, abstract differentiable manifolds, charts, vector fields and flows, vector bundles, tensor fields, covariant derivatives, parallel transport, Riemannian metrics, geodesics, Riemann curvature tensor. Complete manifolds, Hopf-Rinow theorem. Many examples including curves, surfaces, hyperbolic space, $S^3$, the unit quaternions, the Gauss-Bonnet theorem, etc.

Literature
John M. Lee: Introduction to Smooth Manifolds
John M. Lee: Introduction to Riemannian Manifolds

This following books were inherited from before. The only one I know is Do Carmo.
- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie, Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Problem-solving
Social Competencies
- Sensitivity to Diversity
Personal Competencies
- Creative Thinking
- Critical Thinking

401-3461-00L Functional Analysis I
At most one of the three course units (Bachelor Core Courses)
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory
can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract
Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed graph theorem; spectral theory of self-adjoint operators in Hilbert spaces. Basics of Sobolev spaces.

Objective
Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature
Recommended references include the following:

Prerequisites / notice
Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH. Most importantly: fluency with point set topology and measure theory, in part. Lebesgue integration and $L^p$ spaces.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Problem-solving
Personal Competencies
- Creative Thinking
- Critical Thinking

Proseminars and Semester Papers
Detailed information at:
https://www.phys.ethz.ch/studies/master/semester-projects.html

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<tr>
<td>402-0218-MSL</td>
<td>Research Project</td>
<td>W</td>
<td>8</td>
<td>15A</td>
<td>Supervisors</td>
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</table>

Abstract
Students conduct a small research project within a research group or carry out a guided self-study of original papers on a given theoretical topic. The results are submitted in a written report and an oral presentation.

Objective
- Students are enabled to:
  - expand their knowledge in a specific area of physics,
  - conduct a project (a) in a research laboratory or (b) on a specific topic of theoretical physics,
  - discuss their project results and conclusions in a team,
  - present their findings in written and oral form.

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Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: fostered
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

402-0219-MSL Research Project II

To register, please contact the study administration at studies.physics@ethz.ch

W 8 credits 15A Supervisors

Abstract
Students conduct a small research project within a research group or carry out a guided self-study of original papers on a given theoretical topic. The results are submitted in a written report and an oral presentation.

Objective
Students are enabled to:
- expand their knowledge in a specific area of physics,
- conduct a project (a) in a research laboratory or (b) on a specific topic of theoretical physics,
- discuss their project results and conclusions in a team,
- present their findings in written and oral form.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: fostered
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH
see Science in Perspective: Type A: Enhancement of Reflection Capability
Recommended Science in Perspective (Type B) for D-PHYS

Master's Thesis

Number Title Type ECTS Hours Lecturers
402-2000-00L Scientific Works in Physics O 0 credits D. Kienzler

Abstract
Target audience: Master students who cannot document to have received an adequate training in working scientifically.

Directive

Abstract
Literature Review: ETH-Library, Journals in Physics, Google Scholar; Thesis Structure: The IMRAD Model; Document Processing: LaTeX and BibTeX, Mathematical Writing, AVETH Survival Guide; ETH Guidelines for Integrity; Authorship Guidelines; ETH Citation Etiquettes; Declaration of Originality.

Objective
Basic standards for scientific works in physics: How to write a Master Thesis. What to know about research integrity.

462-0900-00L Master's Thesis O 30 credits 57D Supervisors

Abstract
The Master's thesis is normally conducted in the fourth semester and concludes the degree programme. With the Master's thesis students verify their ability to undertake independent and scientifically structured work in the area of high energy physics.

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Objective

Students are enabled to:
- solve a complex problem by applying theoretical and experimental methods and skills,
- articulate their beliefs and thoughts on a scientific subject, appreciate the positions of others and revisit their own positions based on new insights,
- contribute constructively to the projects of a diverse research team,
- actively participate in a scientific discourse on a specific area of physics and present positions based on scientific arguments.

Prerequisites / notice

The time limit for completing the Master’s thesis is six months.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management assessed

High-Energy Physics (Joint Master with IP Paris) - Key for Type

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<td>O</td>
<td>Compulsory</td>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

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<td>D</td>
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ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
In this module, students get an overview of the structure (anatomy) and function (physiology) of the peripheral and central nervous system.

ECTS: 5 credits

- O. Distler, M. Ganter, 5V, F. Allain, K. Köhler

Objectives:
- The students are able to participate in team discussions with correct technical language in the clinical daily routine.
- The students are able to describe the function of the musculoskeletal system of healthy people in a physiologically correct way.
- The students are able to contribute to a therapy plan based on their knowledge of the regenerative capacity of the different tissues in the musculoskeletal system.
- The students recognize pain as a leading symptom in diagnostics and successful therapy.
- The students can assign and compare treatment methods for the most common acute and chronic clinical pictures.

Content:
The students learn about the structure and function of the musculoskeletal system and important disorders on the basis of exemplary clinical pictures. They also learn:
- About its tissue types as well as its function and regeneration.
- Important acute and chronic clinical pictures and their therapeutic principles.
In addition, further clinical pictures are presented in the form of seminars.

Abstract:
Structure and function of the human musculoskeletal system including its major disorders (acute and chronic).

Lecturers:
J. Goldhahn, O. Distler, M. Ganter, C. Maake, M. Steinwachs, further lecturers

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Subject: Nervous System

ECTS: 5 credits


Objectives:
Upon successful completion of this module, students should be able to:
1. Distinguish important cell types of the nervous system (neurons, glial cells) on the basis of their structure and function;
2. Correctly describe neurophysiological basics of stimulus conduction and processing in the peripheral and central nervous system;
3. Correctly name the organ structures and circuits involved in the development of the peripheral and central nervous system;
4. Associate the different brain areas with corresponding functions in homeostasis, sensory, motor and cognitive functions;
5. Identify clinical pictures associated with the loss of function of certain structures of the central and peripheral nervous system and to understand the mode of action of current therapeutic approaches.

Content:
In this module, students get an overview of the structure (anatomy) and function (physiology) of the peripheral and central nervous system as well as selected neurological diseases (pathophysiology).

- The module is subdivided into a total of six subject areas:
  1. Basics of neurophysiology, stimulus conduction and processing using the example of the motor end plate, peripheral nervous system, associated clinical pictures (myasthenia gravis)
  2. Structure, circuits and pathways in the spinal cord, spinal nerves, motor stimulus conduction in the spinal cord, spinal cord lesions and pain
  3. Anatomy and function of the brain stem and cranial nerves and their significance for motor and sensory functions, lesions (brain stem syndromes)
  4. Anatomy and function of basal ganglia, thalamus and hypothalamus, control of the autonomic nervous system (homeostasis, food and water intake), basal ganglia defects using Parkinson’s disease as an example
  5. Anatomy and function of the cerebellum and vestibular system, fine control of motor functions, associative learning, cerebellar symptoms (ataxias), organ of equilibrium
  6. Anatomy and function of the cerebrum, sensory and motor processing, cognition, learning and memory, neurodegenerative (Alzheimer) and neuropsychiatric (schizophrenia) disorders

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Subject: Molecular Genetics and Cell Biology

ECTS: 5 credits

- J. Corn, F. Allain, K. Köhler

Objectives:
1) Students can explain the importance of evolution for the development of humans and diseases.  
2) The students know the cell as the smallest unit of the body. They can explain how the functions of the cell are disturbed in certain diseases and where therapies intervene. They can describe the multiplication of cells in the body and show how errors in this multiplication can lead to diseases.  
3) The students know DNA as the basis of life. They can explain how the DNA information is stored and how this information can be reproduced and protected from damage. They can describe how the information is read and translated into proteins. They can explain which mechanisms at the level of DNA, RNA and proteins can cause diseases.  
4) Students can explain which technologies can be used to diagnose and treat diseases.  
5) Students can explain how people differ genetically and know the molecular basis of these differences. They can explain how these differences can lead to diseases and why some of these differences do not affect diseases.  
6) The students know the molecular causes of the most common hereditary diseases and can determine the probability of occurrence and transmission to offspring.  
7) Students can explain the biochemical and molecular basis of human reproduction and know the basic principles of human embryonic development. The students can explain which mechanisms can be disturbed by a faulty development.  

Lecture notes:
See Moodle

Literature:
- “Biology - how life works”, Morris et al.  
- “Evolutionary Analysis”, Herron & Freeman  
- “Genetics: From Genes To Genomes”, Goldberg & Fischer  
- “Molecular Biology of the Cell”, Alberts et al.

Prerequisites / notice:
The lecture is accompanied by exercises on Moodle (BYOD: http://www.ethz.ch/byod), group projects and mid-terms (learning elements). Upon successful completion of the learning elements (at least 80% of the total possible points must be achieved), students can receive bonus points, which can be credited towards the grade of the final examination. Acquiring points from the group projects and the mid-terms requires on-site participation (no online participation possible). Acquiring bonus points is not a prerequisite for taking part in the final exam.

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Abstract
The lecture teaches the most important fundamental concepts in chemistry (atomic structure, chemical bonds, thermodynamics and kinetics of chemical reactions, acid-base equilibria, types and reactivity of organic compounds, stereochemistry, biomolecules). Connections of chemical processes with medically important biochemical, physiological, and pharmacological questions are highlighted.

Objective
Understanding of the basic concepts of chemistry. Understanding the importance of chemical processes in human physiology and in the diagnosis and treatment of human disease.

Content
The lecture elaborates the fundamental concepts of chemistry. The organization of the lecture is guided by the two textbooks "Chemie für Mediziner" by Zeeck et al. and Schmuck et al., respectively, referred to below. Accordingly, the following major subject areas will be covered: Atomic structure, periodic table of the elements, types of chemical bonds, states of matter, heterogeneous equilibria, thermodynamics and kinetics of chemical reactions, salt solutions, acids and bases, oxidation and reduction, metal complexes, fundamentals of organic chemistry, important classes of organic compounds and their reactivities, stereochemistry, amino acids and peptides, carbohydrates, lipids, heterocycles, spectroscopy in chemistry and medicine.

Literature
Scripts for individual subject areas will be provided electronically prior to the corresponding lectures.

Additional First Year Courses

Table: First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-0281-00L</td>
<td>Mathematics I</td>
<td>O</td>
<td>4</td>
<td>3V+1U</td>
<td>S. Kalisnik Hintz</td>
</tr>
</tbody>
</table>

Abstract
Introduction of mathematics as the universal language for scientific facts; The lecture aims on one hand at learning and exercising the mathematical trade and in the other hand at applying the learnt concept to medical, biological, chemical and mechanical problems.

Objective
Simple and complex facts can be described and analysed using mathematical tools. Introduction to calculus in one dimension. Used concepts: the notion of a function, of the derivative and the integral, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. Applications e.g. to prognoses, modeling action and dosage of drugs or tumor growth.

Content
Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

Literature
G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag
Further reading suggestions will be indicated during the lecture.

Competencies
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Problem-solving: assessed
- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: fostered
- **Personal Competencies**
  - Critical Thinking: assessed
  - Creative Thinking: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

Table: Additional First Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
Fundamental principles of human medicine, Basic Life Support (BLS) and introduction to histology and microscopy.
After completion of the course, the students:
- have a basic understanding of elementary building blocks and processes as a basis for human medicine, e.g. cell structure and cycle.
- know basic terminology of anatomy.
- understand the process of medical care from first aid to rehabilitation.
- understand the advantages and disadvantages of emergency diagnostics, especially ultrasound.
- know the basics of microscopy and histology.
- have learned the basics of Basic Life Support:
  - recognize the symptoms of cardiovascular arrest.
  - alarm in an emergency according to the situation.
  - if available, they organize an AED and use it correctly and as quickly as possible.
  - perform sufficient chest compressions on the phantom.
  - perform effective ventilation on the phantom using a pocket mask.
  - will identify possible ventilation complications. Under certain circumstances, they will not attempt further ventilation.
  - will identify the limits of cardiopulmonary resuscitation.
  - under stress, they do not risk their own or other "helpers'" lives.

Based on a complex clinical case, students are familiarized with the course of medical care from initial treatment to rehabilitation. Basic terms, modules and processes are introduced. In addition, the students experience the basics of imagining techniques, especially ultrasound.

The students complete the Basic Life Support course. After this training sequence, all participants should be able to initiate resuscitation measures in private and in-hospital settings.

The students experience learning, teaching and working in the hospital sector as a social process and teamwork in which all senses and a wide range of skills are needed.

In addition, the students experience in three workshops the basic process of a psychotherapeutic intervention with the concepts of clinical reasoning, therapeutic aspects and therapy progression.

An intensive course in microscopy/histology enables students to perform microscopy independently and to understand histological sections of a histological sample, but also online.

### Second Year Courses

#### Organ Systems, Clinical Practice and Natural Sciences

#### Examination Block A

<table>
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<tr>
<th>Number</th>
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<td>377-0301-00L</td>
<td>Medical Interviewing Technique</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>S. Markun, K. Weiss, to be announced</td>
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</tbody>
</table>

**Abstract**

Interviewing techniques to acquire medically relevant information and building an adequate physician-patient relationship.

**Objective**

- the components of a strucured medical interview
- The students can:
  - perform a structured medical interview
  - initiate an adequate relation to patients

**Content**

Mixed teaching methods, including lectures and training in groups with real patients and simulated patients.

#### Prerequisites / notice

The course is supported by a Moodle page through which students have access to all necessary documentation.

The course material will be available on the course's Moodle page in the form of lesson handouts.

Suggested reference books include:

- Blood: Hoffbrand's Essential Haematology
- Immune system: Herbert Hof, Rüdiger Dörries; unter Mitarbeit von: Gernot Geginat, Dirk Schlüter und Constanze Wendt Medizinische Mikrobiologie Thieme 2017

#### Prerequisites

The immune system part of this course builds on the content of the "Infection" course.

#### Nutrition and Digestion

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<td>Nutrition and Digestion</td>
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<td>5 credits</td>
<td>5V</td>
<td>W. Langhans, L. Käser, C. Stockmann</td>
</tr>
</tbody>
</table>

**Abstract**

This module imparts basic knowledge about the morphology and function of the digestive system and the importance of nutrition for health.

One focus is on the understanding of the relationships among food intake, digestion, nutrient absorption and metabolism including the disturbances of these processes and the related diseases.
The aim of this module is that the students know and understand the morphology and function of the digestive system including its associated glands as well as the importance of nutrition for health. In particular, the students shall understand the relationships between food intake and digestion as well absorption and metabolism of particular nutrients. This knowledge shall enable the students to deduce the pathophysiology and pathology of the most important diseases of the digestive system and shall give them an idea of the pertinent diagnostics and therapy.

Subject-specific Competencies

Concepts and Theories

Assessed

Methods-specific Competencies

Analytical Competencies

Assessed

Problem-solving

Assessed

377-0301-03L Endocrinology, Metabolism

ECTS

5

Objectives

1. To acquire knowledge about the morphology and function of the endocrine system and its role in metabolism. 
2. To learn about the regulation of hormone secretion, transport of hormones, half-lives, degradation and excretion of hormones.
3. To understand the basics of hormone classes: protein and polypeptide hormones, amino and amino acid derivatives, polypeptide hormones, and hormone classes.
4. To learn about the structure and function of the various endocrine glands.

Content

- Hormone classes: Protein and polypeptide hormones, amino acid derivatives, steroid hormones, proteins, and polypeptide hormones, biosynthesis of protein and amino acid derivatives, biosynthesis of steroid hormones, storage of hormones, secretion of hormones, transport of hormones, half-lives, degradation and excretion of hormones.
- Transmission of information by hormones: hormone action at receptors, structure and function of membrane-associated hormone receptors, structure and function of nuclear receptors, regulation of hormone secretion.
- Structure and function of the hypothalamus, structure and function of the pituitary gland.
- Structure and function of the thyroid gland, under- and over-functioning of the thyroid gland, principles of diagnostics and therapy of thyroid diseases. Symptoms, medical history and clinical examination of thyroid diseases.
- Bones, calcium and phosphate metabolism.
- Hormone classes: Protein and polypeptide hormones, amino acid derivatives, steroid hormones, proteins, and polypeptide hormones, biosynthesis of protein and amino acid derivatives, biosynthesis of steroid hormones, storage of hormones, secretion of hormones, transport of hormones, half-lives, degradation and excretion of hormones.
- Transmission of information by hormones: hormone action at receptors, structure and function of membrane-associated hormone receptors, structure and function of nuclear receptors, regulation of hormone secretion.
- Neuronal innervation and vascular supply area of the endocrine glands.
- Hormone classes: Protein and polypeptide hormones, amino acid derivatives, steroid hormones, proteins, and polypeptide hormones, biosynthesis of protein and amino acid derivatives, biosynthesis of steroid hormones, storage of hormones, secretion of hormones, transport of hormones, half-lives, degradation and excretion of hormones.
- Transmission of information by hormones: hormone action at receptors, structure and function of membrane-associated hormone receptors, structure and function of nuclear receptors, regulation of hormone secretion.
- Structure and function of the hypothalamus, structure and function of the pituitary gland.
- Structure and function of the thyroid gland, under- and over-functioning of the thyroid gland, principles of diagnostics and therapy of thyroid diseases. Symptoms, medical history and clinical examination of thyroid diseases.
- Neuronal innervation and vascular supply area of the endocrine glands.
- Regulation of hormone secretion, transport of hormones, half-lives, degradation and excretion of hormones.
- Structural and functional aspects of endocrine pancreas, pathogenesis of different types of diabetes mellitus. Principles of diagnostics and therapy of type 1 and type 2 diabetes.
- Structure and function of the adrenal gland, pathogenesis, principles of diagnostics and therapy of diseases with hyper- and hypofunction of the adrenal gland. Symptoms, anamnesis and clinical examination in case of hyper- and hypofunction of the adrenal gland.
- Structure and function of the ovaries and testis, principles of reproductive physiology.

Literature

The essential course material will be available on the course’s Moodle Page in the form of scripts and lesson handouts.

Method-specific Competencies

LE 377-0203-00L Atmungs-System

LE 377-0107-00L Nervensystem

LE 377-0105-00L Bewegungsapparat

Voraussetzungen:

- Physik I
- Physik II
- Mathematik I
- Mathematik II

Prerequisites

The course builds on the content of the "Chemie für Mediziner" course and "Nutrition and Digestion".

Lecture notes

There is no traditional script for this course. Instead the course is supported by a Moodle page through which students have access to all necessary texts, exercises, videos and activities.

Prerequisites / notice

- Mathematik I
- Mathematik II
- Physik I
- Physik II

- Voraussetzung Mathematik I II (Studiengänge Gesundheitswissenschaften und Technologie bzw. Humanmedizin / Mathematik-Lehreinrichtungen des Basisjahres (Studiengänge Chemie, Chemieingenieurwissenschaften bzw. Interdisziplinäre Naturwissenschaften)

- "Physik für Mediziner, Biologen, Pharmazeuten", von Alfred Trautwein, Uwe Kreibig, Jürgen Hüttermann: De Gruyter Verlag.

- "Physik für Mediziner, Biologen, Pharmazeuten", von Alfred Trautwein, Uwe Kreibig, Jürgen Hüttermann: De Gruyter Verlag.

- "Physik für Mediziner, Biologen, Pharmazeuten", von Alfred Trautwein, Uwe Kreibig, Jürgen Hüttermann: De Gruyter Verlag.

- "Physik für Mediziner, Biologen, Pharmazeuten", von Alfred Trautwein, Uwe Kreibig, Jürgen Hüttermann: De Gruyter Verlag.

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Courses in Medical Sciences

Core Courses 2nd Year

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>401-0683-00L</td>
<td>Statistics II</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>B. Ineichen</td>
</tr>
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</table>

Abstract
Extension of statistics for medical students. This lecture is based on the content of Statistics I. The focus will be on the understanding and the concrete application of statistical methods, as they are used in medical research. Exercises will be solved using the statistical programming environment R.

Objective
After this course you will understand the concept of a broad selection of statistical methods (see also Content). Furthermore, you will know when to use which method. Especially, you will be able to read, understand, and scrutinise the results from such methods, whether these results are written or graphical.

Content
The course will cover the following topics:
- For the part on regression: simple linear regression; multiple regression (including factors and interactions); model selection; logistic regression (including odds ratio and their interpretation); Bayes inference.
- For the part on data: categorical data (including univariate tests); power analysis (including a guide on writing an ethics proposal); dealing with missing values.
- For the part on further methods: supervised vs unsupervised learning; dimensional reduction (including PCA and tSNE); survival analysis (including Kaplan-Meier curves and logrank test).

Lecture notes
There is no script.

Literature
An Introduction to Statistical Learning with Applications in R
Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani
Springer, 2013; online available from the ETH Library

Compensatory Courses

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>376-0201-00L</td>
<td>Materials and Mechanics in Medicine</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Zenobi-Wong, J. G. Snedeker</td>
</tr>
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</table>

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
course website on Moodle

Literature
Introduction to Biomedical Engineering, 3rd Edition 2011,
Author: John Enderle, Joseph Bronzino, ISBN 9780123749796
Academic Press

376-1103-00L

Frontiers in Nanotechnology

<table>
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<th>Lecturers</th>
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<tr>
<td>W</td>
<td>Frontiers in Nanotechnology</td>
<td></td>
<td>4</td>
<td>4V</td>
<td>V. Vogel, further lecturers</td>
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Abstract
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Objective
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the-art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes
All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

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### 376-1714-00L Biocompatible Materials

**W** 4 credits 3V

K. Maniura, M. Rottmar, M. Zenobi-Wong

**Objective**

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**

Introduction to natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**

Handouts are deposited online (moodle).

**Literature**


(available online via ETH library)

### 376-1721-00L Bone Biology: Basics, Research and Clinics

**W** 2 credits 2V

E. Wehrle, G. A. Kuhn, to be announced

**Abstract**

The course gives an introduction into bone biology and provides an overview on current research methods and clinical approaches. Emphasis is put on skeletal development and metabolism, osteoporosis as well as fracture healing. Each topic is structured into three parts: basics, research and clinics.

**Objective**

After completing the Bone Biology course, students will be able to:

1. Remember and apply basics in bone biology and disease
2. Remember clinical features and surgical approaches
3. Select adequate research methods and approaches
4. Evaluate publications on topics presented in the lecture

**Competencies**

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### 376-1651-00L Clinical and Movement Biomechanics

**W** 4 credits 3G

D. K. Ravi, S. H. Hosseini Nasab, R. List, further lecturers

**Abstract**

Measurement and modeling of the human movement during daily activities and in a clinical environment. The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

**Objective**

This course includes study design, measurement techniques, clinical testing, accessing movement data and analysis as well as modeling with regards to human movement.

**Content**

4. Introduction to different material classes in use for medical applications.
3. Introduction into methodology used in biomaterials research and application.
2. The concept of biocompatibility.
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.

**Literature**


A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

### 535-0022-00L Computer-Assisted Drug Design

**W** 1 credit 1V

S. Riniker, G. Landrum

**Abstract**

The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

**Objective**

The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

**Content**

The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).

**Lecture notes**

Script will be available.

**Literature**

Recommended textbooks:

Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Objective

Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Content

Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics.

Lecture notes

Biotransformation of drugs and xenobiotics

Literature


Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Media and Digital Technologies assessed

Problem-solving assessed

Personal Competencies

Adaptability and Flexibility fostered

Creative Thinking fostered

Critical Thinking fostered

535-0250-00L Biotransformation of Drugs and Xenobiotics W 1 credit 1V S.-D. Krämer

Abstract

Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Objective

Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Factors which affect the biotransformation.

Content

Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics.

J. W.

Creative Thinking fostered

Adaptability and Flexibility fostered

Analytical Competencies assessed

Biotransformation of drugs and xenobiotics

Literature


Competencies

Subject-specific Competencies

Concepts and Theories assessed

Analytical Competencies assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

535-0310-00L Glycobiology in Drug Development W 1 credit 1V V. I. Otto

Abstract

Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.

Objective

Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:

- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
- the major types of protein-linked glycans and the biosynthetic pathways for their formation
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

Students gain the ability to reflect on roles of glycosylation in various biological contexts.

Content

lecture plan:

1. Glycans - information carriers in biology and pharmacotherapy
2. Glucocerebrosidase and the biosynthesis of N-glycans
3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs
5. gCQA analysis of glycoprotein hormone drugs (sialylated glycoproteins)
6. EPO "the same but different"

Lecture notes

The slides used for the lectures will be provided online

Literature

- recent publications as cited/proposed on the lecture slides

Prerequisites / notice

Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology.

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Social Competencies assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

Integrity and Work Ethics assessed

535-0423-00L Drug Delivery and Drug Targeting W 2 credits 1.5V J.-C. Leroux

Abstract

The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective

The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content

The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes

Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature


Further references will be provided in the course.
551-0307-00L  Molecular and Structural Biology I: Protein Structure and Function  
D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course

Abstract  
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective  
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

551-0309-00L  Concepts in Modern Genetics

Information for UZH students:  
Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Abstract  
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective  
This course focuses on the concepts of classical and modern genetics and genomics.

Content  
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

551-0313-00L  Microbiology (Part I)

Abstract  
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective  
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content  
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes  
Updated handouts will be provided during the class.

Literature  
Current literature references will be provided during the lectures.

Prerequisites / notice  
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant cellular and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

### Content

- Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.
- Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

### Literature

- Recommended supplementary literature (review articles and selected primary literature) will be provided during the course. Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

### Prerequisites / notice

- To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

### Competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- Method-specific Competencies
  - Analytical Competencies: fostered
  - Critical Thinking: fostered

- Personal Competencies
  - Communication: fostered
  - Creative Thinking: fostered
  - Critical Thinking: fostered

### Courses in Organ Systems and Clinical Practice

#### Additional Courses 3rd Year

<table>
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<th>Number</th>
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<th>ECTS</th>
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<tr>
<td>377-0501-00L</td>
<td>Reproduction</td>
<td>O</td>
<td>4</td>
<td>5V</td>
<td>P. Imesch, G. Hasenberg, B. Leeners, C. Maake, R. Messmer,</td>
</tr>
</tbody>
</table>
Abstract

In this module we lay the anatomical and physiological foundations for the subject of "reproduction". The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and shows the normal female cycle and her disorders as well as the pregnancy and related issues to the obstetrics. Students will have the opportunity to work with prospective midwives to learn basic skills of normal birth through a simulation.

Objective

1. correctly describe the biological bases of the aging process;
2. derive physical and pharmacological choices to modulate the aging process;
3. understand the social and psychological implication of aging;
4. describe the specificities of geriatric medicine in the stationary setting;
5. identify the age-specific differences in both diagnostics and therapeutics.

Content

This module gives the anatomical and physiological foundations for the subject of "reproduction". The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and shows the normal female cycle and her disorders as well as the pregnancy and related issues to the obstetrics. Students will have the opportunity to work with prospective midwives to learn basic skills of normal birth through a simulation.

Prerequisites / notice

Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Harnleiter
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0503-01L Geriatrics

Abstract

Fundamentals and relevance of the aging process, as well as its biochemical, physiological and evolutionary basis. Insights into its individual as well as economic impact, including interventional and pharmacological treatment options.

Objective

1. correctly describe the biological bases of the aging process;
2. derive physical and pharmacological choices to modulate the aging process;
3. understand the social and psychological implication of aging;
4. describe the specificities of geriatric medicine in the stationary setting;
5. identify the age-specific differences in both diagnostics and therapeutics.

Content

This module gives the anatomical and physiological foundations for the subject of "reproduction". The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and shows the normal female cycle and her disorders as well as the pregnancy and related issues to the obstetrics. Students will have the opportunity to work with prospective midwives to learn basic skills of normal birth through a simulation.

Prerequisites / notice

Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Harnleiter
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0503-02L Rheumatology

Abstract

Disease patterns from the field of rheumatology. The main focus is on inflammatory diseases, including soft tissue and bone diseases.

Objective

At the end of the module, students should be able to do the following:
• list the typical symptoms and manifestations of the disease patterns;
• list the clinical examinations of the clinical pictures and explain the findings;
• list and justify further clarifications (such as laboratory tests, imaging, etc.) of the clinical pictures;
• recognize the respective clinical pictures of this topic block based on the symptoms, clinical examinations, findings and further clarifications;
• list the possible treatment options for the disease patterns and explain the indication, prevention and risk factors;
• Early detection of clinical pictures that require rapid therapy, identification of further steps for clarification and therapy;
• describe the causes and pathophysiological basis of the disease patterns.

Content

Overview Rheumatology, Rheumatoid Arthritis, M. Still, Spondyloarthritis, SAPHO Syndrome, Infectious and Crystal Arthritis, Juvenile Idiopathic Arthritis, CRPS, Soft Tissue Diseases, Myopathies, Bone Diseases, Vasculitis, Collagenosis, Drug Therapy in Rheumatology, Ergonomics, Occupational Reintegration.

Prerequisites / notice

Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Harnleiter
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane
Abstract
The module Paediatrics describes the peculiarities of the paediatric anamnesis as well as selected topics of the healthy and sick child. The focus is on the newborn, development in the first years of life and adolescence. Infections, congenital heart and the most common respiratory diseases are described throughout the different age stages.

Objective
• Knowledge of the paediatric aspects of the medical history
• Knowledge of the enormous variety of child development (inter- and intra-individual variability)
• Milestone concept: Assessment of the stage of development of a child in the first years of life
• Landmark concept: first knowledge of the demilitation on normality versus disorder
• Getting to know frequent developmental pediatric disorders
• Knowledge of the most common congenital heart defects
• Getting to know and recognize respiratory diseases of the upper and lower respiratory tract

Content
It describes the peculiarities of the pediatric anamnesis as well as selected topics of the healthy and sick child. The focus is on the newborn, development in the first years of life and adolescence. Infections, congenital heart, and the most common respiratory diseases are described throughout the different age stages.

Prerequisites / notice
Prerequisites:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

Abstract
Pathology is the study of causes and effects of disease. This module pathology describes the pathogenetic processes and pathomorphological changes that occur in healthy and diseased tissues and cells of the human body. The module covers basic anatomical and surgical pathology and will cover the current and future possibilities of diagnostic practice in pathology.

Objective
After successfully completing the «General Pathology» module, students should be able to
1. to describe the goals and methods of pathoanatomical diagnostics and in reference to clinical practice.
2. to name the general causes and mechanisms of disease development and the associated pathomorphological changes in cells and tissues.
3. to fundamentally link the general causes and mechanisms of disease development with the therapeutic approaches that arise from them.
4. to describe the mechanisms of general inflammation, cell damage and circulatory pathology and relate them to the pathogenesis of specific diseases.
5. to explain the basics of the classification of benign and malignant tumors.
6. to describe the value of pathoanatomical and molecular diagnostics for the predictive and prognostic stratification of patients and to fundamentally relate them to clinical therapy decisions.

After successfully completing the «Surgical Pathology» module, students should be able to
1. to name the most important organ-specific diseases of the nervous system, the endocrine system, the cardiovascular system, the respiratory system, the digestive system, the urogenital system, the musculoskeletal system and the skin and to describe their characteristic macroscopic and microscopic manifestations.
2. to relate the etiology and pathogenesis of the most important organ-specific diseases to their morphological appearance and clinical presentation.
3. to describe the etiopathogenesis of the most important organ-specific diseases and to understand the relation to the mode of action of common therapeutic approaches.
4. to describe the fundamental importance of pathology and molecular diagnostics for personalized medicine and to describe specific application examples.
In the module "General Pathology" general causes and mechanisms of disease development and the associated pathomorphological changes in cells and tissues are discussed. Basics, current and future possibilities of pathoanatomical diagnostics are presented. The module "General Pathology" provides the basics for understanding the diseases treated in "Special Pathology".

The general pathology part covers the main topics:
1. revision and in-depth histology
2. introduction to pathology, histopathological and macroscopic tissue evaluation, postmortem diagnostics
3. introduction to causes and mechanisms of disease development
4. inflammation theory
5. cell damage and circulation pathology
6. general tumor theory
7. predictive pathology

In the module "Special Pathology" you will learn about the most important organ-specific diseases. Each half-day is built around a complex of topics related to special pathology, and is implemented using various teaching methods. The most important part is the main lecture, in which we systematically discuss the diseases of the organs and organ systems with you. Using macroscopic and microscopic slides, we will show you the relation to pathophysicsology, symptomatology and medical diagnostics. We establish clinical references by broadcasting the mortality conference at the USZ. An integrated revision course and exercises based on PathoMaps offer you the opportunity to link the subject matter of the lecture with already known contents, to structure it further and to clarify open points together. A special lecture on molecular pathology, digital pathology and bioinformatics will introduce you to future technologies that are of particular importance for modern medicine.

The special pathology part covers the main topics:
1. upper and lower respiratory tract
2. upper gastrointestinal tract
3. lower gastrointestinal tract
4. liver, gall bladder, pancreas
5. kidney, draining urinary tract
6. male sexual organs, prostate
7. future technologies (molecular pathology, digital pathology, bioinformatics)
8. blood and bone marrow, lymphatic system
9. endocrine organs
10. skin, bones, joints, soft tissue
11. female sexual organs, mamma
12. neuropathology

Prerequisites / notice
Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

<table>
<thead>
<tr>
<th>377-0511-00L Emergency Medicine</th>
<th>O 2 credits 2P</th>
<th>M. Guigli Poretti</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
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<tr>
<td>By focusing on the 20 most frequent emergencies, the students will learn how to make quick decisions including diagnostic strategy and therapeutic measures. In practical exercises the students practice interprofessional aspects and discuss legal and ethical questions of emergency medicine.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Perform a triage based on the assessment of the vital signs.</td>
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<td>Collect a targeted anamnesis (max. 5-6 questions) of a patient and/or family member</td>
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<td>Determine the status of a patient with the necessary clinical examinations.</td>
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<td>Determine a differential diagnosis based on the targeted anamnesis and the status.</td>
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<td>Interpret the vital signs of a patient</td>
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<td>Interpret the results of the paraclinical examinations and confirm/reject the differential diagnosis.</td>
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<td>Based on the differential diagnosis, determine the necessary paraclinical examinations</td>
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<td>Determine the next steps (treatment in hospital / by family doctor / immediate measures)</td>
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<td>Identify possible therapeutic measures</td>
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<td>Content</td>
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<td>Mornings – case discussions &amp; lectures entire group:</td>
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<td>• Hypo / Hyperglycemia</td>
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<td>• Principles of poisoning</td>
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<td>• Acute Dyspnoea</td>
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<td>• Cough</td>
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<td>• Acute Diarrhoea</td>
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<td>• Gastrointestinal bleeding</td>
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<td>• Acute Kidney injury</td>
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<td>• Chest Pain</td>
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<td>• Syncope</td>
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<td>• Acute Abdominal pain</td>
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<td>• Acute blood loss</td>
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<td>• Common Trauma</td>
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<td>• Head Trauma</td>
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<td>• Fever in child</td>
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<td>• Crying child</td>
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<td>• Seizures and convulsions</td>
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<td>• Dyspnoea in child</td>
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<td>Afternoon – 4 smaller groups rotating:</td>
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<tr>
<td>• Emergency room (Hospital Lugano)</td>
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<td>• Emergency call-center / Ambulance (Croce Verde - Lugano)</td>
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<td>• Simulation center (Lugano)</td>
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<td>• Case discussion (Bellinzona)</td>
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<td>• BLS Refresh</td>
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</table>
### 377-0513-00L Ethics, Legal Aspects and Communication

**Abstract**
The students develop the basics of medical law, clinical ethics and communication needed for central applications in the clinic. They learn which relevant legal framework conditions are to be observed in everyday clinical practice and how, in communication with patients, the principles of self-determination, patient well-being and damage avoidance are practically implemented.

**Objective**
After passing the module successfully, students should be able to
- Know about ethical and legal basics of diagnostics and therapy and how these principles are put into practice
- Knowledge and use of central communication skills with patients, health care teams and the public
- Understand and describe the connections of ethics, law and communication and reflect on the implementation in clinical practice
- Apply the concept of evidence based decision aids
- Apply specific communication skills in simple clinical cases (informed consent, shared decision making, breaking bad news, communication of medical mistakes, Advance care Planning)
- Understand the concept and needs of vulnerable patients and address the concept ethically, legally and communicate adequately
- Know about the necessity of interprofessional collaboration in the process of dealing with ethically and juridically complex cases and practice first steps.

**Content**
- Overview of clinical ethical cases
- Basics in medical ethics and professional communication
- Knowledge and application of concepts as informed consent, possible alternative juridical instruments
- Knowledge and Application of Shared Decision Making
- Knowledge and application of advance care planning, concept of advance directives, treatment of patients incapable of decision making
- Breaking bad news, difficult prognoses
- Concept of vulnerability, special needs
- Differences of research/clinical, concept of evidence-based and personalized medicine
- Conflicts of interests in therapy and research
- Basics on interprofessional cooperation in ethically and legally challenging situations
- Goal of care approach; deling with end of life decisions
- Differential diagnoses and misdiagnosis, systems of avoidance of medical mistakes

**Prerequisites / notice**
- LE 377-0405-10L Ethik in Medizin und Gesundheitswesen
- Organsysteme der ersten vier Semester (Prüfungen absolviert)

### 377-0515-00L Patient Journeys

**Abstract**
The module deals with the importance of patient care by combining patient and interprofessional perspectives as well as the cooperation with other healthcare professions, at any moment (out- and inpatient treatment) as the patient progress along a care pathway.

**Objective**
- The students are able to analyze an interprofessional patient-path and modify it according to the personal patient situation.
- Students deal with other health professionals and together plan an appropriate patient-path.
- The students are able to take different perspectives (patient, family etc.) and consider them while planning a patient-path.
- Students actively participate in interprofessional sessions, are open to other viewpoints, and consider these for the care and safety of the patients.

**Content**
Based on various patient situations, students learn how an interprofessional patient-path looks like.

During the self-study time, the students bring “their own patient” from their private environment and accompany her/him during the patient-path. Within this framework the individual path including all health professionals involved, will be analyzed. In a written assignment, the most important steps will be documented and reflected.

An exemplary patient case follows each session of the modules, to align the theoretical inputs with the corresponding patient care.

During the first session, the students analyze various internet platforms such as NetDoktor and learn how to deal with an informed patient. In addition, together with pharmacy students, the students get to know the different roles of the pharmacy. In further sessions, the students learn which responsibilities, tasks and competences, various health professionals have, during the care of the patients on their path.

In addition, the students have the opportunity to visit a rural hospital in another canton and become acquainted with the importance of the free choice of doctors and treatments in other Cantons.

**Prerequisites / notice**
- LE 377-0405-10L Ethik in Medizin und Gesundheitswesen
- LE 377-0105-00L Bewegungsapparat
- LE 377-0104-00L Bewegungsapparat
- LE 377-0201-00L Herz-Kreislauf-System
- LE 377-0203-00L Atemungs-System
- LE 377-0205-00L Nieren und Homöostase
- LE 377-0301-01L Blut, Immunsystem
- LE 377-0301-02L Ernährung und Verdauung
- LE 377-0301-03L Endokrinologie, Stoffwechsel
- LE 377-0401-00L Sinnesorgane
- LE 377-0403-00L Haut und Anhangsorgane

### 377-0517-00L Oncology

**Abstract**
Advances in our knowledge of cancer genetic and the cancer immunology are changing the ways by which clinicians treat various types of cancer. This is a unique course designed to help students to learn about cutting-edge principles of cancer genetic, cancer immunology and target therapy and to apply these concepts to the clinical practice guided by leading experts in the field.

**Objective**
Students will learn basic concepts of cancer patients' management and will acquired knowledge regarding experimental and clinically approved anti-cancer therapies.
Content

Basic knowledge in oncology
1. The cancer outbreak and its prevention
2. Tumor diagnostic, imaging and screening
3. Basic principle of cancer management and tumor recurrence
4. Clinical application: a clinical case study

Experimental immuno-oncology
1. Hallmarks of Cancer
2. The promise of Immuno-oncology
3. Experimental Immunotherapies: Checkpoint Blockade and CAR T cells
4. From Bedside to Bench to Bedside (Journal Club)

Targeted therapy
1. Cancer Genomics and Epigenomics
2. Basic knowledge of signal transduction and cancer metabolism
3. From Arsenic Trioxide and Glivec to modern targeted therapies
4. Mechanism of resistance to targeted therapies

Oncology practice
1. Basic and clinical application: Chemotherapy
2. Basic and clinical application: Radiotherapy
3. Clinical application: Evidence Based Medicine in oncology
4. Design and analysis of Clinical Trial
5. Clinical application: Immunotherapy
6. Clinical application: Target Therapy
7. From Symptoms to diagnosis
8. Oncology Emergency

Prerequisites / notice
Prerequisites:
- LE 377-0105-00L Bewegungsapparat
- LE 377-0107-00L Nervensystem
- LE 377-0201-00L Herz-Kreislauf-System
- LE 377-0203-00L Atmungs-System
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- LE 377-0401-00L Sinnesorgane
- LE 377-0403-00L Haut und Anhangsorgane

377-0519-00L Ultrasound Basics

Abstract
Zurich Ultrasound-Modell (ETH/SGUM/UZH) for ultrasound profiles (curricular) and SGUM certificate basic course abdomen during medical studies (SGUM-Young Sonographers, facultative) with E-Learning and 8 hours practical teaching with 4 students per machine and instructor (curricular), as well as facultative 8 more hours practice and OSCE in the following semester.

Objective
Ultrasound basics
- Understanding of basic ultrasound physics.
- Basic ultrasound anatomy abdomen.
- To know and to do a typical Abdomen and soft-tissue ultrasound examination.
- Classical ultrasound pathology (Aszites, pleural effusion, gallstones, urinary retention ...).
- Know the most important artefacts and relevance for ultrasound imaging.
- SGUM basic abdomen certificate sucessful determination

Content
Modules curricular teaching ETHZ
- 1+2 Anatomy
- 3+4 Liver, biliary tract, pleura, rips, lung
- 5+6 Pankreas, spleen, adrenals, abdominal vessels
- 7+8 kidneys, bladder, neck, lymphnodes, FAST
- SGUM – Young Sonographers (facultative in the 6th Semester BSc Human Medicine)
- 9+10
- 10+11
- 11+12
- 13+14

Prerequisites / notice
Ultraschall Theorie
Voraussetzung:
LE 377-0311-00L Praktikum klinische Anatomie

Courses in Medical Sciences
Core Courses 3rd Year

Number Title Type ECTS Hours Lecturers
252-0866-00L Foundations of Computer Science for Human Medicine O 2 credits 2G M. Dahinden, L. E. Fässler

Abstract
This course provides important basic concepts for interdisciplinary programming projects with Python.

Objective
Students learn to...
- encode a problem into a program, test the program, and correct errors.
- understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- implement models from the natural sciences as a simulation.
- explain and apply standard algorithms and evaluate their efficiency.

Content
1. Variables, data types
2. Control structures, logic
3. Sequential data types, search- and sort algorithms, sequence analysis
4. Functions, modules, simulation and cellular automata

Lecture notes
All learning materials will be provided during the course.
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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<td>Assessed</td>
<td>Assessed</td>
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<td>Problem-solving</td>
<td>Media and Digital Technologies</td>
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<td>Assessed</td>
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<td>Project Management</td>
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<td>Fostered</td>
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</table>

**Social Competencies**

- Communication: Fostered
- Cooperation and Teamwork: Fostered

**Personal Competencies**

- Adaptability and Flexibility: Fostered
- Critical Thinking: Assessed
- Self-awareness and Self-reflection: Fostered
- Self-direction and Self-management: Fostered

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**377-0523-00L Medical Technology I**

**Abstract**

The course will guide students through the user-centered development and evaluation process of a medical engineering system for arm movement support. It will introduce the fundamentals of data acquisition, signal processing and control engineering, complemented by hands-on experience with sensors/signals, actuators, signal processing, feedback/feedforward control as well as 3D design/printing.

**Objective**

The course enables students to:

- prepare for the collaboration with engineers, and understand their approach to the analysis and characterization of technical challenges
- describe the user-centered design and evaluation process of a medical engineering system
- explain the fundamentals of data acquisition, signal processing and controls engineering
- interpret measurements of physiological signals and analyze these for noise contributions
- acquire practical experience with sensors/signals, actuators, signal processing, controls as well as 3D design/printing

**Content**

The course covers the interdisciplinary elements of a medical engineering development and its evaluation, ranging from human factors to sensor and actuator technologies, (real-time) signal processing, control engineering basics as well as safety/ethical aspects. It is framed around the electrophysiological assessment and robotic movement support following spinal cord injury, and complemented with practical training on a didactic elbow exoskeleton.

### Prerequisites / notice

- Voraussetzungen: LE 402-0083-00L Physik I
- LE 402-0684-00L Physik II

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**376-0021-00L Materials and Mechanics in Medicine**

**Abstract**

Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Objective**

Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Content**

- Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

**Lecture notes**

- course website on Moodle

**Literature**

- Academic Press

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**376-1103-00L Frontiers in Nanotechnology**

**Abstract**

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.
Objective

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<th>W</th>
<th>Lecturer(s)</th>
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<tbody>
<tr>
<td>376-1651-00L</td>
<td>Clinical and Movement Biomechanics</td>
<td>4</td>
<td>3G</td>
<td></td>
<td>D. K. Ravi, S. H. Hosseini Nasab, R. List, further lecturers</td>
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<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>4</td>
<td>3V</td>
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<td>K. Maniura, M. Rottmar, M. Zenobi-Wong</td>
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<tr>
<td>376-1721-00L</td>
<td>Bone Biology: Basics, Research and Clinics</td>
<td>2</td>
<td>2V</td>
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<td>E. Wehrle, G. A. Kuhn, to be announced</td>
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</tbody>
</table>

Abstract

Measurement and modeling of the human movement during daily activities and in a clinical environment.

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequesnces of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes

Handouts are deposited online (moodle).

Literature


(available online via ETH library)

Handouts and references therin.

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<thead>
<tr>
<th>Code</th>
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<td></td>
<td>E. Wehrle, G. A. Kuhn, to be announced</td>
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</tbody>
</table>
The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

**Abstract**
The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

**Contents**
The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).

**Lecture notes**
Script will be available.

**Literature**
Recommended textbooks:

**Competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
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<td>Analytical Competencies</td>
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**535-0022-00L Computer-Assisted Drug Design**

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**Objective**
The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

**Lecture notes**
Script will be available.

**Literature**
Recommended textbooks:

**Competencies**

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**535-0250-00L Biotransformation of Drugs and Xenobiotics**

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**Objective**
Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

**Lecture notes**
Biotransformation of drugs and xenobiotics

**Literature**

**Competencies**

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**535-0310-00L Glycobiology in Drug Development**

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**Objective**
Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:
- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
- the major types of protein-linked glycans and the biosynthetic pathways for their formation.
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

Students gain the ability to reflect on roles of glycosylation in various biological contexts.
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Further references will be provided in the course.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIOC348 at UZH.

Please mind the ETH enrolment deadlines for UZH

Data: 02.07.2024 12:39
Autumn Semester 2024
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Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

This course focuses on the concepts of classical and modern genetics and genomics.

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Scripts and additional material will be provided during the semester.

The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

The concepts, methods and explanatory power of evolutionary genetics.

Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding, natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.

Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crosses; effects on fitness; Fisher's fundamental theorem.

Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

Handouts

Molecular Biology of Foodborne Pathogens

**Abstract**
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

**Objective**
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

**Content**
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

**Literature**
Recommendations will be given in the first lecture

**Prerequisites / notice**
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

**Further Modules**
This course cannot be counted towards the Bachelor Human Medicine. However, the students receive a certificate for completion of each Skills Lab.

**Bachelor Studies (Programme Regulations 2018)**

**Courses in Organ Systems and Clinical Practice**

**Additional Courses 3rd Year**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
377-0501-00L | Reproduction | O | 4 credits | 5V | P. Imesch, G. Hasenberg, B. Leeners, C. Maake, R. Messmer, N. Ochsenbein-Kölble

**Abstract**
In this module we lay the anatomical and physiological foundations for the subject of "reproduction". The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and goes from the normal cycle of the woman and her disorders to the pregnancy and related issues to the obstetrics.

**Objective**
- Anatomy
  - Knowledge of the function of the female and male sexual organs
  - Explaining the development of the maternal and fetal parts of the placenta
  - Explaining the anatomy of the pelvis and the pelvic floor
  - Gynecology
  - Recognizing gynecological emergencies
  - Listing of the various types of bleeding an irregularities
  - Overview of the benign tumors of the uterus and ovaries as well as the malignant tumors of the cervix and the endometrium
  - Reproductive Endocrinology
    - Outlining of the main regulatory hormones of the female cycle and explaining their effects
    - Listing of the most important sterility factors
    - Discussing the main contraceptive methods with their mechanisms of action and contraceptive safety
  - Physiological situations in obstetrics
    - Knowledge of the physiological processes and adaptation processes during pregnancy
    - Determination of birth process
    - Being aware of the meaning of the puerperium

**Content**
This module gives the anatomical and physiological foundations for the subject of "reproduction". The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and shows the normal female cycle and her disorders as well as the pregnancy and related issues to the obstetrics. Students will have the opportunity to work with prospective midwives to learn basic skills of normal birth through a simulation.
Prerequisites / notice

Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauß-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0503-01L Geriatrics O 1 credit 1V J. Goldhahn, C. Ewald, A. Fischer, to be announced, further lecturers

Abstract
Fundamentals and relevance of the aging process, as well as its biochemical, physiological and evolutionary basis. Insights into its individual as well as economic impact, including interventional and pharmacological treatment options.

Objective
Upon successful completion of the module, students should be able to
1. correctly describe the biological bases of the aging process;
2. derive physical and pharmacological choices to modulate the aging process;
3. understand the social and psychological implication of aging;
4. describe the specificities of geriatric medicine in the stationary setting;
5. identify the age-specific differences in both diagnostics and therapeutics.

Content
Fundamentals and relevance of the aging process, as well as its biochemical, physiological and evolutionary basis. Insights into its individual as well as economic impact, including interventional and pharmacological treatment options.

Prerequisites / notice

Prerequisites:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauß-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
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LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0503-02L Rheumatology O 2 credits 2V S. Blumhardt, M. O. Becker, R. Micheroli, C.-M. Mihai, further lecturers

Abstract
Disease patterns from the field of rheumatology. The main focus is on inflammatory diseases, including soft tissue and bone diseases.

Objective
At the end of the module, students should be able to do the following:
• list the typical symptoms and manifestations of the disease patterns;
• list the clinical examinations of the clinical pictures and explain the findings;
• list and justify further clarifications (such as laboratory tests, imaging, etc.) of the clinical pictures;
• recognize the respective clinical pictures of this topic block based on the symptoms, clinical examinations, findings and further clarifications;
• list the possible treatment options for the disease patterns and explain the indication, prevention and risk factors;
• Early detection of clinical pictures that require rapid therapy, identification of further steps for clarification and therapy;
• describe the causes and pathophysiological basis of the disease patterns.

Content
Overview Rheumatology, Rheumatoid Arthritis, M. Still, Spondyloarthritids, SAPHO Syndrome, Infectious and Crystal Arthritis, Juvenile Idiopathic Arthritis, CRPS, Soft Tissue Diseases, Myopathies, Bone Diseases, Vasculitis, Collagenosis, Drug Therapy in Rheumatology, Ergonomics, Occupational Reintegration.

Prerequisites / notice

Prerequisites:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauß-System
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LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0503-03L Paediatrics O 2 credits 2V M. Seiler, C. Berger, A. Möller, C. Schaefer, M. Wolff, further lecturers

Abstract
The module Paediatrics describes the peculiarities of the paediatric anamnesis as well as selected topics of the healthy and sick child. The focus is on the newborn, development in the first years of life and adolescence. Infections, congenital heart and the most common respiratory diseases are described throughout the different age stages.

Objective
• Knowledge of the paediatric aspects of the medical history
• Knowledge of the enormous variety of child development (inter- and intra-individual variability)
• Milestone concept: Assessment of the stage of development of a child in the first years of life
• Landmark concept: first knowledge of the demilation on normality versus disorder
• Getting to know frequent developmental pediatric disorders
• Knowledge of the most common congenital heart defects
• Getting to know and recognize respiratory diseases of the upper and lower respiratory tract

Content
It describes the peculiarities of the pediatric anamnesis as well as selected topics of the healthy and sick child. The focus is on the newborn, development in the first years of life and adolescence. Infections, congenital heart, and the most common respiratory diseases are described throughout the different age stages.
Pathology is the study of causes and effects of disease. This module pathology describes the pathogenetic processes and pathomorphological changes that occur in healthy and diseased tissues and cells of the human body. The module covers basic anatomical and surgical pathology and will cover the current and future possibilities of diagnostic practice in pathology.

Objective

After successfully completing the «General Pathology» module, students should be able to:

1. to describe the goals and methods of pathoanatomical diagnostics and in reference to clinical practice.
2. to name the general causes and mechanisms of disease development and the associated pathomorphological changes in cells and tissues.
3. to fundamentally link the general causes and mechanisms of disease development with the therapeutic approaches that arise from them.
4. to describe the mechanisms of general inflammation, cell damage and circulatory pathology and relate them to the pathogenesis of specific diseases.
5. to explain the basics of the classification of benign and malignant tumors.
6. to describe the value of pathoanatomical and molecular diagnostics for the predictive and prognostic stratification of patients and to fundamentally relate them to clinical therapy decisions.

After successfully completing the «Surgical Pathology» module, students should be able to:

1. to name the most important organ-specific diseases of the nervous system, the endocrine system, the cardiovascular system, the respiratory system, the digestive system, the urogenital system, the musculoskeletal system and the skin and to describe their characteristic macroscopic and microscopic manifestations.
2. to relate the etiology and pathogenesis of the most important organ-specific diseases to their morphological appearance and clinical presentation.
3. to describe the etiopathogenesis of the most important organ-specific diseases and to understand the relation to the mode of action of common therapeutic approaches.
4. to describe the fundamental importance of pathology and molecular diagnostics for personalized medicine and to describe specific application examples.

Content

In the module “General Pathology” general causes and mechanisms of disease development and the associated pathomorphological changes in cells and tissues are discussed. Basics, current and future possibilities of pathoanatomical diagnostics are presented. The module “General Pathology” provides the basics for understanding the diseases treated in “Special Pathology”.

The general pathology part covers the main topics:

1. revision and in-depth histology
2. introduction to pathology, histopathological and macroscopic tissue evaluation, postmortem diagnostics
3. introduction to causes and mechanisms of disease development
4. inflammation theory
5. cell damage and circulation pathology
6. general tumor theory
7. predictive pathology

In the module “Special Pathology” you will learn about the most important organ-specific diseases. Each half-day is built around a complex of topics related to special pathology, and is implemented using various teaching methods. The most important part is the main lecture, in which we systematically discuss the diseases of the organs and organ systems with you. Using macroscopic and microscopic slides, we will show you the relation to pathophysiology, symptomatology and medical diagnostics. We establish clinical references by broadcasting the mortality conference at the USZ. An integrated revision course and exercises based on PathoMaps offer you the opportunity to structure it further and to clarify open points together. A special lecture on molecular pathology, digital pathology and bioinformatics will introduce you to future technologies that are of particular importance for modern medicine.

The special pathology part covers the main topics:

1. upper and lower respiratory tract
2nd upper gastrointestinal tract
3. lower gastrointestinal tract
4. liver, gall bladder, pancreas
5. kidney, draining urinary tract
6. male sexual organs, prostate
7. future technologies (molecular pathology, digital pathology, bioinformatics)
8. blood and bone marrow, lymphatic system
9. endocrine organs
10. skin, bones, joints, soft tissue
11. female sexual organs, mamma
12. neurology

Prerequisites / notice

Voraussetzungen:

LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane
### Emergency Medicine

**377-0511-00L**

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<td>M. Guigli Poretti</td>
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**Abstract**

By focusing on the 20 most frequent emergencies, the students will learn how to make quick decisions including diagnostic strategy and therapeutic measures. In practical exercises the students practice interprofessional aspects and discuss legal and ethical questions of emergency medicine.

**Objective**

- Perform a triage based on the assessment of the vital signs.
- Collect a targeted anamnesis (max. 5-6 questions) of a patient and/or family member
- Determine the status of a patient with the necessary clinical examinations.
- Determine a differential diagnosis based on the targeted anamnesis and the status.
- Interpret the vital signs of a patient
- Interpret the results of the paraclinical examinations and confirm/reject the differential diagnosis.
- Based on the differential diagnosis, determine the necessary paraclinical examinations
- Determine the next steps (treatment in hospital / by family doctor / immediate measures)
- Identify possible therapeutic measures

**Content**

**Mornings – case discussions & lectures entire group:**

- Hypo / Hyperglycemia
- Principles of poisoning
- Acute Dyspnoea
- Cough
- Acute Diarrhoea
- Gastroenteritis bleeding
- Acute Kidney injury
- Hypertensive Crisis
- Acute Headache
- Coma
- Chest Pain
- Syncope
- Acute Abdominal pain
- Acute blood loss
- Common Trauma
- Head Trauma
- Fever in child
- Crying child
- Seizures and convulsions
- Dyspnoea in child

**Afternoon – 4 smaller groups rotating:**

- Emergency room (Hospital Lugano)
- Emergency call-center / Ambulance (Croce Verde - Lugano)
- Simulation center (Lugano)
- Case discussion (Bellinzona)
- BLS Refresh

**Prerequisites / notice**

- LE 377-0101-00L Grundbausteine Mensch
- LE 377-0211-00L Körperliche Untersuchung
- LE 377-0411-00L Internistische Untersuchung
- all Organ systems of 1.-4. Semesters

### Ethics, Legal Aspects and Communication

**377-0513-00L**

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**Abstract**

The students develop the basics of medical law, clinical ethics and communication needed for central applications in the clinic. They learn which relevant legal framework conditions are to be observed in everyday clinical practice and how, in communication with patients, the principles of self-determination, patient well-being and damage avoidance are practically implemented.

**Objective**

- After passing the modul successfully, students should be able to
  - Know about ethical and legal basics of diagnostics and therapy and how these principles are put into practice
  - Knowledge and use of central communication skills with patients, health care teams and the public
  - Understand and describe the connections of ethics, law and communication and reflect on the implementation in clinical practice
  - Apply the concept of evidence based decision aids
  - Apply specific communication skills in simple clinical cases (informed consent, shared decision making, breaking bad news, communication of medical mistakes, Advance care Planning).
  - Understand the concept and needs of vulnerable patients and address the concept ethically, legally and communicate adequately
  - Know about the necessity of interprofessional collaboration in the process of dealing with ethically and juridically complex cases and practice first steps.

**Content**

- Overview of clinical ethical cases
- Basics in medical ethics and professional communication
- Knowledge and application of concepts as informed consent, possible alternative juridical instruments
- Knowledge and application of Shared decision Making
- Knowledge and application of advance care planning, concept of advance directives, treatment of patients incapable of decision making
- Breaking bad news, difficult prognoses
- Concept of vulnerability, special needs
- Differences of research/clinics, concept of evidence-based and personalized medicine
- Conflicts of interests in therapy and research
- Basics on interprofessional cooperation in ethically and legally challenging situations
- Goal of care approach, dealing with end of life decisions
- Differential diagnoses and misdiagnosis, systems of avoidance of medical mistakes

**Prerequisites / notice**

- LE 377-0405-10L Ethik in Medizin und Gesundheitswesen
- LE 377-0410-00L Grundbausteine Mensch
- Organ systems der ersten vier Semester (Prüfungen absolviert)

### Patient Journeys

**377-0515-00L**

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<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>O</td>
<td>C. Schlegel, C. Bachmann, E. Kut Bacs, G. Mang, D. Stämpfl, further lecturers</td>
</tr>
</tbody>
</table>

**Abstract**

The modul deals with the importance of patient care by combining patient and interprofessional perspectives as well as the cooperation with other healthcare professions, at any moment (out- and inpatient treatment) as the patient progress along a care pathway.
Based on various patient situations, students learn how an interprofessional patient-path looks like. During the self-study time, the students bring “their own patient” from their private environment and accompany her/him during the patient-path. Within this framework the individual path including all health professionals involved, will be analyzed. In a written assignment, the most important aspects will be documented and reflected. An exemplary patient case follows each session of the modules, to align the theoretical inputs with the corresponding patient case. During the first session, the students analyze various internet platforms such as NetDoktor and learn how to deal with an informed patient. In addition, together with pharmacy students, the students get to know the different roles of the pharmacy. In further sessions, the students learn which responsibilities, tasks and competences, various health professionals have, during the care of the patients on their path.

In addition, the students have the opportunity to visit a rural hospital in another canton and become acquainted with the importance of the free choice of doctors and treatments in other Cantons.

Objective
- The students are able to analyze an interprofessional patient-path and modify it according to the personal patient situation.
- Students deal with other health professionals and together plan an appropriate patient-path.
- The students are able to take different perspectives (patient, family etc.) and consider them while planning a patient-path.
- Students actively participate in interprofessional sessions, are open to other viewpoints, and consider these for the care and safety of the patients.

Content
Based on various patient situations, students learn how an interprofessional patient-path looks like. During the self-study time, the students bring “their own patient” from their private environment and accompany her/him during the patient-path. Within this framework the individual path including all health professionals involved, will be analyzed. In a written assignment, the most important aspects will be documented and reflected. An exemplary patient case follows each session of the modules, to align the theoretical inputs with the corresponding patient case. During the first session, the students analyze various internet platforms such as NetDoktor and learn how to deal with an informed patient. In addition, together with pharmacy students, the students get to know the different roles of the pharmacy. In further sessions, the students learn which responsibilities, tasks and competences, various health professionals have, during the care of the patients on their path.

In addition, the students have the opportunity to visit a rural hospital in another canton and become acquainted with the importance of the free choice of doctors and treatments in other Cantons.

Prerequisites / notice
Voraussetzungen:
LE 377-0105-00L Bewegungssapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Hombostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0517-00L Oncology

Objective
- Basic knowledge in oncology
1. The cancer outbreak and its prevention
2. Tumor diagnostic, imaging and screening
3. Basic principle of cancer management and tumor recurrence
4. Clinical application: a clinical case study

Experimental immuno-oncology
1. Hallmarks of Cancer
2. The promise of Immuno-oncology
3. Experimental Immunotherapies: Checkpoint Blockade and CAR T cells
4. From Bedside to Bench to Bedside (Journal Club)

Targeted therapy
1. Cancer Genomics and Epigenomics
2. Basic knowledge of signal transduction and cancer metabolism
3. From Arsenic Trioxide and Glivec to modern targeted therapies
4. Mechanism of resistance to targeted therapies

Oncology practice
1. Basic and clinical application: Chemotherapy
2. Basic and clinical application: Radiotherapy
3. Clinical application: Evidence Based Medicine in oncology
4. Design and analysis of Clinical Trial
5. Clinical application: Immunotherapy
6. Clinical application: Target Therapy
7. From Symptoms to diagnosis
8. Oncology Emergency

Prerequisites / notice
Voraussetzungen:
LE 377-0105-00L Bewegungssapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Hombostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0519-00L Ultrasound Basics

Abstract
Zurich Ultrasound-Modell (ETH/SGUM/UZH) for ultrasound profiles (curricular) and SGUM certificate basic course abdomen during medical studies (SGUM-Young Sonographers, facultative) with E-Learning and 8 hours practical teaching with 4 students per machine and instructor (curricular), as well as facultative 8 more hours practice and OSCE in the following semester.

Objective
- Ultrasound basics
  - Understanding of basic ultrasound physics.
  - Basic ultrasound anatomy abdomen.
  - To know and to do a typical Abdomen and soft-tissue ultrasound examination.
  - Classical ultrasound pathology (Aszites, pleural effusion, gallstones, urinary retention ...).
  - Know the most important artefacts and relevance for ultrasound imaging.
  - SGUM basic abdomen certificate successful determination

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Content
Modules curricular teaching ETHZ
- 1+2 Anatomy
- 3+4 Liver, biliary tract, pleura, hips, lung
- 5+6 Pancreas, spleen, adrenals, abdominal vessels
- 7+8 kidneys, bladder, neck, lymphnodes, FAST
SGUM – Young Sonographers (facultative in the 6th Semester BSc Human Medicine)
- 9+10
- 10+11
- 11+12
- 13+14

Prerequisites / notice
Ultrasschall Theorie
Voraussetzung:
LE 377-0311-00L Praktikum klinische Anatomie

Courses in Medical Sciences
Core Courses 3rd Year

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0866-00L</td>
<td>Foundations of Computer Science for Human Medicine</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>M. Dahinden, L. E. Fässler</td>
</tr>
</tbody>
</table>

Abstract
This course provides important basic concepts for interdisciplinary programming projects with Python.

Objective
Students learn to...
- encode a problem into a program, test the program, and correct errors.
- understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- implement models from the natural sciences as a simulation.
- explain and apply standard algorithms and evaluate their efficiency.

Content
1. Variables, data types
2. Control structures, logic
3. Sequential data types, search- and sort algorithms, sequence analysis
4. Functions, modules, simulation and cellular automata

Lecture notes
All learning materials will be provided during the course.

Literature

Prerequisites / notice
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

Competencies
Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Technologies: assessed

Method-specific Competencies
Analytical Competencies: assessed
Decision-making: fostered
Media and Digital Technologies: fostered
Problem-solving: assessed
Project Management: fostered

Social Competencies
Communication: fostered
Cooperation and Teamwork: fostered

Personal Competencies
Adaptability and Flexibility: fostered
Creative Thinking: assessed
Critical Thinking: assessed
Self-awareness and Self-reflection: fostered
Self-direction and Self-management: fostered

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>377-0523-00L</td>
<td>Medical Technology I</td>
<td>O</td>
<td>3</td>
<td>4G</td>
<td>R. Gassert, O. Lambercy</td>
</tr>
</tbody>
</table>

Abstract
The course will guide students through the user-centered development and evaluation process of a medical engineering system for arm movement support. It will introduce the fundamentals of data acquisition, signal processing and control engineering, complemented by hands-on experience with sensors/signals, actuators, signal processing, feedforward/feedback control as well as 3D design/printing.

Objective
The course enables students to:
• prepare for the collaboration with engineers, and understand their approach to the analysis and characterization of technical challenges
• describe the user-centered design and evaluation process of a medical engineering system
• explain the fundamentals of data acquisition, signal processing and controls engineering
• interpret measurements of physiological signals and analyze these for noise contributions
• acquire practical experience with sensors/signals, actuators, signal processing, controls as well as 3 design/printing

Content
The course covers the interdisciplinary elements of a medical engineering development and its evolution, ranging from human factors to sensor and actuator technologies, (real-time) signal processing, control engineering basics as well as safety/ethical aspects. It is framed around the electrophysiological assessment and robotic movement support following spinal cord injury, and complemented with practical training on a didactic elbow exoskeleton.

Prerequisites / notice
Voraussetzungen:
LE 402-0083-00L Physik I
LE 402-0684-00L Physik II
Compensatory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-0021-00L</td>
<td>Materials and Mechanics in Medicine</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Zenobi-Wong, J. G. Snedeker</td>
</tr>
<tr>
<td>Abstract</td>
<td>Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.</td>
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<tr>
<td>Objective</td>
<td>Understanding of physical and technical principles in biomaterials, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.</td>
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<tr>
<td>Content</td>
<td>Biocompatible Materials</td>
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<tr>
<td>Lecture notes</td>
<td>course website on Moodle</td>
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<tr>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>W</td>
<td>4</td>
<td>4V</td>
<td>V. Vogel, further lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontsiers.</td>
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<tr>
<td>Objective</td>
<td>Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.</td>
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<tr>
<td>Content</td>
<td>Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.</td>
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<tr>
<td>Lecture notes</td>
<td>All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.</td>
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<th>Hours</th>
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<tbody>
<tr>
<td>376-1651-00L</td>
<td>Clinical and Movement Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. K. Ravi, S. H. Hosseini Nasab, R. List, further lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Measurement and modeling of the human movement during daily activities and in a clinical environment. The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.</td>
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<tr>
<td>Objective</td>
<td>This course includes study design, measurement techniques, clinical testing, accessing movement data and anyas well as modeling with regards to human movement.</td>
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<tr>
<td>Content</td>
<td>The course covers the following topics: 1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials. 2. The concept of biocompatibility. 3. Introduction into methodology used in biomaterials research and application. 4. Introduction to different material classes in use for medical applications.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts are deposited online (moodle).</td>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>W</td>
<td>4</td>
<td>3V</td>
<td>K. Manaíra, M. Rottmar, M. Zenobi-Wong</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The course covers the following topics: 1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials. 2. The concept of biocompatibility. 3. Introduction into natural and polymeric biomaterials used in biomaterials research and application. 4. Introduction to different material classes in use for medical applications.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts are deposited online (moodle).</td>
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</tbody>
</table>
The course gives an introduction into bone biology and provides an overview on current research methods and clinical approaches. Emphasis is put on skeletal development and metabolism, osteoporosis as well as fracture healing. Each topic is structured into three parts: basics, research and clinics.

After completing the Bone Biology course, students will be able to:

1. Remember and apply basics in bone biology and disease
2. Remember clinical features and surgical approaches
3. Select adequate research methods and approaches
4. Evaluate publications on topics presented in the lecture

The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models). All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

Literature:

Handouts and references therin.

Literature:
(available online via ETH library)

376-1721-00L Bone Biology: Basics, Research and Clinics W 2 credits 2V E. Wehrle, G. A. Kuhn, to be announced

Abstract
The course gives an introduction into bone biology and provides an overview on current research methods and clinical approaches. Emphasis is put on skeletal development and metabolism, osteoporosis as well as fracture healing. Each topic is structured into three parts: basics, research and clinics.

Objective
After completing the Bone Biology course, students will be able to:

1. Remember and apply basics in bone biology and disease
2. Remember clinical features and surgical approaches
3. Select adequate research methods and approaches
4. Evaluate publications on topics presented in the lecture

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork assessed
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

535-0022-00L Computer-Assisted Drug Design W 1 credit 1V S. Riniker, G. Landrum

Abstract
The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

Objective
The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

Content
The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).

Lecture notes
Script will be available.

Literature
Recommended textbooks:

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered

535-0250-00L Biotransformation of Drugs and Xenobiotics W 1 credit 1V S.-D. Krämer

Abstract
Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Objective
Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Content
Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics. Toxic reactions of metabolites. Factors which affect the biotransformation.

Lecture notes
Biotransformation of drugs and xenobiotics

Literature

Competencies
Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking fostered
Glycobiology in Drug Development

535-0310-00L

Abstract
Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.

Objective
Students gain basic knowledge in “pharmaceutical glycobiology”. This implies knowing and understanding:
- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
- the major types of protein-linked glycans and the biosynthetic pathways for their formation
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).
Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

Content
lecture plan:
1. Glycans - information carriers in biology and pharmacotherapy
2. Glucocerebrosidase and the biosynthesis of N-glycans
3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
4. Mucin-type-O-glycans and sialylation as gCQA of glycoprotein hormone drugs
5. qCQA analysis of glycoprotein hormone drugs (sialylated glycoproteins)
6. EPO "the same but different"

Lecture notes
The slides used for the lectures will be provided online

Literature
- recent publications as cited/proposed on the lecture slides

Prerequisites / notice
Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed

535-0423-00L

Drug Delivery and Drug Targeting

W 2 credits 1.5V J.-C. Leroux

Abstract
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective
The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature

Further references will be provided in the course.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed

Personal Competencies
Negotiation fostered
Adaptability and Flexibility assessed
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

551-0307-00L

Molecular and Structural Biology I: Protein Structure and Function

D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.
551-0309-00L Concepts in Modern Genetics

**Content**
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**
This course covers the concepts of classical and modern genetics and genomics.

**Literature**
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

**Competencies**
- Concepts and Theories: assessed
- Technics and Technologies: assessed
- Analytical Competencies: assessed
- Problem-solving: assessed
- Communication: fostered
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Creative Thinking: assessed
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**Lecture notes**
Scripts and additional material will be provided during the semester.

551-0313-00L Microbiology (Part I)

**Abstract**
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Objective**
This course will be based on common concepts and will introduce students to the enormous diversity among bacteria and archaebacteria. It will cover principles of classical genetics, yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Literature**
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

**Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Problem-solving: assessed
- Communication: fostered
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Creative Thinking: assessed
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

551-0319-00L Cellular Biochemistry (Part I)

**Abstract**
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function, and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemical of cellular physiology. Investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Literature**

**Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Problem-solving: assessed
- Communication: fostered
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Creative Thinking: assessed
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

701-2413-00L Evolutionary Genetics

**Abstract**
The concept course "Evolutionary Genetics" consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).
Objective
The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content
- Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding, natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.
- Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher's fundamental theorem.
- Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

Lecture notes
Handouts

Literature

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Personal Competencies
  - Critical Thinking

ECTS
- 3 credits
- 2V

M. Loessner, A. Harms, M. Schuppler, E. Slack

752-4009-00L Molecular Biology of Foodborne Pathogens

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Social Competencies
  - Communication
- Personal Competencies
  - Creative Thinking
  - Critical Thinking

Further Modules

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<th>Hours</th>
<th>Lecturers</th>
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<td>377-0682-00L</td>
<td>Skills Lab (Autumn Semester)</td>
<td>W</td>
<td>0</td>
<td>1U</td>
<td>M. Useini, C. Schiegel</td>
</tr>
</tbody>
</table>

Abstract
The Skills Lab MED is available to medical students at ETH as a place to learn and practice practical skills and abilities. Various courses are continuously offered in peer tutoring or with lecturers.

Content
The following skills are offered:
- Placemnt of a peripheral indwelling canula (in peer teaching)
- Optimization of ultrasound device settings, neck & thyroid sonography (Peer Teaching)
- Ultrasound-guided peripheral venipuncture
- Suturing course
- Wound bandage

Human Medicine Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>E</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
<thead>
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<th>Type</th>
<th>Description</th>
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<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
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<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Information Systems for Engineers

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
### Computer Science II

**Z 4 credits 2V+2U**

R. Sasse, F. Friedrich Wicker

**Abstract**
The courses covers the foundations of design and analysis of algorithms and data structures, including graph theory and graph problems. It also introduces generic and parallel programming.

**Objective**
Understanding design, analysis and implementation of fundamental algorithms and data structures. Overview of the concepts of generic and parallel programming. Hands-on experience with implementing the aforementioned in C++.

**Content**
- Asymptotic runtime (algorithmic complexity)
- Fundamental algorithmic problems, e.g. searching, sorting, shortest paths, spanning trees
- Classical data structures, e.g. search trees, balanced trees, heaps, hash tables
- Graph theory and graph problems
- Problem solving strategies as design patterns for algorithms, e.g. induction, divide and conquer, backtracking, dynamic programming
- Generic programming: C++ templates higher-order functions, lambdas, closures
- Parallel programming: (in)dependence of computations, parallelism and concurrency, shared memory, races, mutual exclusion, communication and synchronisation

Knowledge obtained in the lecture is deepened through practical and/or programming exercises (C++, Code Expert).

**Lecture notes**
All material (slides, lecture recordings, examples, exercises, etc.) will be published on the course website.

**Literature**
- B. Stroustrup, A Tour of C++, 3rd Edition, Addison-Wesley, 2022

**Prerequisites / notice**
Prerequisite: Computer Science I

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### Informatics

**Z 2 credits 2G**

M. Dahinden, L. E. Fässler

**Abstract**
Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists, tables and relational databases, introduction to programming.

**Objective**
The students learn to...
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data,
- query databases and understand and evaluate the corresponding database model,
- encode a problem into a program, test the program, and correct errors,
- implement models from the natural sciences as a simulation.

**Content**
1. Modeling and simulations
2. Data management with lists and tables
3. Data management with a relational database
4. Introduction to programming with Python 1 (variables & data types)
5. Introduction to programming with Python 2 (control structures & logic)
6. Introduction to programming with Python 3 (sequential data structures)

**Lecture notes**
All materials for the lecture are available at www.evim.ethz.ch

**Literature**

**Prerequisites / notice**
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.
Competencies | Subject-specific Competencies | Concepts and Theories | fostered
---|---|---|---
Method-specific Competencies | Analytical Competencies | fostered
Decision-making | Media and Digital Technologies | assessed
Problem-solving | Project Management | fostered
Social Competencies | Communication | assessed
Cooperation and Teamwork | fostered
Personal Competencies | Adaptability and Flexibility | fostered
Creative Thinking | Critical Thinking | assessed
Self-awareness and Self-reflection | Self-direction and Self-management | fostered

252-0845-00L Computer Science I Z 5 credits 2V+2U M. Lüthi, A. Streich

Abstract
The course covers the basic concepts of computer programming.

Objective
Basic understanding of programming concepts. Students will be able to write and read simple programs and to modify existing programs. In the course "Computer Science I", the competency of programming is taught, applied and examined. Furthermore modeling is taught and applied.

Content
variables, types, control structures, functions, scoping, recursion, object-oriented programming. The programming language is Python.

Lecture notes
The slides and lecture notes will be made available for download on the course website.

Literature
Learn to Code by Solving Problems
A Python Programming Primer
Eric Matthes

Python Crash Course
A Hands-On, Project-Based Introduction to Programming
Daniel Zingaro

Python for Data Analysis
Data wrangling with pandas, NumPy & Jupyter, 3rd Edition
Wes McKinney

Competencies
Subject-specific Competencies | Concepts and Theories | assessed
---|---|---
Method-specific Competencies | Analytical Competencies | assessed
Decision-making | Media and Digital Technologies | assessed
Problem-solving | fostered
Social Competencies | Communication | fostered
Cooperation and Teamwork | fostered
Personal Competencies | Creative Thinking | fostered
Critical Thinking | fostered

252-0847-00L Computer Science Z 5 credits 2V+2U M. Fischer, F. Friedrich Wicker

Abstract
The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

Objective
Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.

Content
The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

Lecture notes
Lecture slides and all other material will be made available for download on the course web page.

Literature
Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000

Competencies
Subject-specific Competencies | Concepts and Theories | assessed
---|---|---
Method-specific Competencies | Analytical Competencies | assessed
Decision-making | Media and Digital Technologies | assessed
Problem-solving | fostered
Social Competencies | Communication | fostered
Cooperation and Teamwork | fostered
Personal Competencies | Creative Thinking | fostered
Critical Thinking | fostered

252-0852-00L Foundations of Computer Science Z 4 credits 2V+2U M. Dahinden, L. E. Fässler

Abstract
This course provides selected computer science concepts for interdisciplinary projects.

The following topics are covered: introduction to programming, sequence analysis, modeling and simulations, introduction matrices, managing data with with relational databases.

Objective
Students learn to...
- encode a problem into a program, test the program, and correct errors.
- understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- query databases and understand and evaluate the corresponding database model.
- implement models from the natural sciences as a simulation.
- run random experiments and interpret the results.
- explain and apply standard algorithms and evaluate their efficiency.
The main topics of the course unit "Computer Science in Secondary School Mathematics" represent a scientific and didactic added value for mathematics classes.

The course covers the didactics of logic, of cryptography, of finite state automata, of computability and of the introduction to programming. The students develop the understanding of fundamental scientific concepts such as algorithm, program, complexity, determinism, computation, automata, verification, testing, security of a cryptosystem and secure communication. They reflect on ways to embed them into a scientifically sound and didactically sustainable mathematics course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Content
1. Variables, data types
2. Control structures, logic
3. Sequential data types, search- and sort algorithms, sequence analysis
4. Functions, modules, simulation and animation
5. Analytical Competencies
   - Concepts and Theories
   - Techniques and Technologies
   - Analytical Competencies
   - Decision-making
   - Media and Digital Technologies
   - Problem-solving
   - Project Management
   - Communication
   - Cooperation and Teamwork
   - Adaptability and Flexibility
   - Critical Thinking
   - Self-awareness and Self-reflection
   - Self-direction and Self-management
6. Matrices, random experiments, cellular automata
7. Social Competencies
   - Language skills
   - Group work
   - Essay writing
   - Problem solving

5G
1. Variables, data types
2. Control structures, logic
3. Sequential data types, search- and sort algorithms, sequence analysis
4. Functions, modules, simulation and animation
5. Analytical Competencies
   - Concepts and Theories
   - Techniques and Technologies
   - Analytical Competencies
   - Decision-making
   - Media and Digital Technologies
   - Problem-solving
   - Project Management
   - Communication
   - Cooperation and Teamwork
   - Adaptability and Flexibility
   - Critical Thinking
   - Self-awareness and Self-reflection
   - Self-direction and Self-management
6. Matrices, random experiments, cellular automata
7. Social Competencies
   - Language skills
   - Group work
   - Essay writing
   - Problem solving

3G
1. Variables, data types
2. Control structures, logic
3. Sequential data types, search- and sort algorithms, sequence analysis
4. Functions, modules, simulation and animation
5. Analytical Competencies
   - Concepts and Theories
   - Techniques and Technologies
   - Analytical Competencies
   - Decision-making
   - Media and Digital Technologies
   - Problem-solving
   - Project Management
   - Communication
   - Cooperation and Teamwork
   - Adaptability and Flexibility
   - Critical Thinking
   - Self-awareness and Self-reflection
   - Self-direction and Self-management
6. Matrices, random experiments, cellular automata
7. Social Competencies
   - Language skills
   - Group work
   - Essay writing
   - Problem solving
Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.

The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

Lecture slides and all other material will be made available for download on the course web page.

This course introduces both theoretical and applied aspects of software engineering. It covers:

- Software Architecture
- Informal and formal Modeling
- Design Patterns
- Software Engineering Principles
- Code Refactoring
- Program Testing

The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking of a computer scientist.

In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

Lecture slides and all other material will be made available for download on the course web page.

This course introduces both theoretical and applied aspects of software engineering. It covers:

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Creative Thinking
- Critical Thinking

While the lecture will provide the theoretical foundations for the various aspects of software engineering, the students will apply those techniques in project work that will span over the whole semester - involving all aspects of software engineering, from understanding requirements over design and implementation to deployment and change requests.
Computer Science Colloquium

Abstract
Invited talks, covering the entire scope of computer science. External Listeners are welcome at no charge. A detailed schedule is published at the beginning of each semester.

Objective
Top international computer scientists take the floor at the distinguished computer science colloquium. Our guest speakers present impacting topics across various areas of the discipline. The colloquium series is held every semester and also includes inaugural and farewell lectures of the department's professors. The colloquium is a noteworthy event for all graduate students. Outside attendance is equally welcome.

Content
Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.

Colloquium on Mathematics, Computer Science, and Education

Abstract
Didactics colloquium

Computer Science (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Type</th>
</tr>
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<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>W+</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>W</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
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<table>
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<th>Key for Hours</th>
<th>Description</th>
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<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
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<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
Many people can write programs. The "Introduction to Programming" course goes beyond that basic goal: it teaches the fundamental
Content: Mathematical reasoning and proofs, abstraction. Sets, relations (e.g. equivalence and order relations), functions, (un-)countability,
algorithm theory.

The primary goals of this course are (1) to introduce the most important concepts of discrete mathematics, (2) to understand and
appreciate the role of abstraction and mathematical proofs, and (3) to discuss a number of applications, e.g. in cryptography, coding theory,
and algorithm theory.

See course description.

The lecture slides are available for download on the course page.

See the course page for up-to-date information.

There are no special prerequisites. Students are expected to enroll in the other courses offered to first-year students of computer science.

A complete script in German is under development. A complete draft is already available on the course website.

Gilbert Strang, Introduction to Linear Algebra, 6th Edition, Wellesley - Cambridge Press. Further literature and links can be found on the

The course introduces software engineering principles with an object-oriented approach based.

Many people can write programs. The "Introduction to Programming" course goes beyond that basic goal: it teaches the fundamental
courses and skills necessary to perform programming at a professional level. As a result of successfully completing the course, students
master the fundamental control structures, data structures, reasoning patterns and programming language mechanisms characterizing
modern programming, as well as the fundamental principles of producing high-quality software. They have the necessary programming
background for later courses introducing programming skills in specialized application areas.

Basics of object-oriented programming. Objects and classes. Pre- and postconditions, class invariants, design by contract. Fundamental
data structures and algorithms. Recursion, Inheritance and interfaces, basic concepts of Software Engineering such as the software process, specification and documentation, debugging, reuse and quality assurance.

The lecture slides are available for download on the course page.

See the course page for up-to-date information.

There are no special prerequisites. Students are expected to enroll in the other courses offered to first-year students of computer science.

A complete script in German is under development. A complete draft is already available on the course website.

Gilbert Strang, Introduction to Linear Algebra, 6th Edition, Wellesley - Cambridge Press. Further literature and links can be found on the

First Year Examination Block 2

Offered in the spring semester.

Basic Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>252-0057-00L</td>
<td>Theoretical Computer Science</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>D. Komm, H.-J. Böckenhauer, J. Hromkovic</td>
</tr>
</tbody>
</table>

Abstract
Concepts to cope with:  
a) what can be accomplished in a fully automated fashion (algorithmically solvable)  
b) How to measure the inherent difficulty of tasks (problems)  
c) What is randomness and how can it be useful?  
d) What is nondeterminism and what role does it play in CS?  
e) How to represent infinite objects by finite automata and grammars?

Objective
Learning the basic concepts of computer science along their historical development

Content
This lecture gives an introduction to theoretical computer science, presenting the basic concepts and methods of computer science in its historical context. We present computer science as an interdisciplinary science which, on the one hand, investigates the border between the possible and the impossible and the quantitative laws of information processing, and, on the other hand, designs, analyzes, verifies, and implements computer systems.

The main topics of the lecture are:

- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

Lecture notes
The lecture is covered in detail by the textbook "Theoretical Computer Science".

Literature
Basic literature:


Further reading:


More exercises and examples in:

6. A. Asteroth, Ch. Baier: Theoretische Informatik

Prerequisites / notice
During the semester, two non-obligatory test exams will be offered.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0061-00L</td>
<td>Systems Programming and Computer Architecture</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>A. Klimovic, T. Roscoe</td>
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Abstract
Introduction to systems programming. C and assembly language, floating point arithmetic, basic translation of C into assembler, compiler optimizations, manual optimizations. How hardware features like superscalar architecture, exceptions and interrupts, caches, virtual memory, multicore processors, devices, and memory systems function and affect correctness, performance, and optimization.
Objective

The course objectives are for students to:

1. Develop a deep understanding of, and intuition about, the execution of all the layers (compiler, runtime, OS, etc.) between programs in high-level languages and the underlying hardware: the impact of compiler decisions, the role of the operating system, the effects of hardware on code performance and scalability, etc.

2. Be able to write correct, efficient programs on modern hardware, not only in C but high-level languages as well.

3. Understand Systems Programming as a complement to other disciplines within Computer Science and other forms of software development.

This course does not cover how to design or build a processor or computer.

Content

This course provides an overview of "computers" as a platform for the execution of (compiled) computer programs. This course provides a programmer's view of how computer systems execute programs, store information, and communicate. The course introduces the major computer architecture structures that have direct influence on the execution of programs (processors with registers, caches, other levels of the memory hierarchy, supervisor/kernel mode, and I/O structures) and covers implementation and representation issues only to the extend that they are necessary to understand the structure and operation of a computer system.

The course attempts to expose students to the practical issues that affect performance, portability, security, robustness, and extensibility. This course provides a foundation for subsequent courses on operating systems, networks, compilers and many other courses that require an understanding of the system-level issues. Topics covered include: machine-level code and its generation by optimizing compilers, address translation, input and output, trap/event handlers, performance evaluation and optimization (with a focus on the practical aspects of data collection and analysis).

Lecture notes

- C programming
- Integers
- Pointers and dynamic memory allocation
- Basic computer architecture
- Compiling C control flow and data structures
- Code vulnerabilities
- Implementing memory allocation
- Linking
- Floating point
- Optimizing compilers
- Architecture and optimization
- Caches
- Exceptions
- Virtual memory
- Multicore
- Devices

Literature

The course is based in part on "Computer Systems: A Programmer's Perspective" (3rd Edition) by R. Bryant and D. O'Hallaron, with additional material.

Prerequisites / notice

252-0029-00L Parallel Programming
252-0028-00L Design of Digital Circuits

401-0213-16L Analysis II

Abstract
Differential and Integral calculus in many variables, vector analysis.

Literature
Für allgemeine Informationen, sehen Sie bitte die Webseite der Vorlesung

401-0663-00L Numerical Methods for Computer Science

Abstract
The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.

Objective
* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently
## Content

First two weeks: A gentle introduction to C++

1. Computing with Matrices and Vectors
   1.1 Fundamentals
   1.2 Software and Libraries
   1.4 Computational Effort
   1.5 Machine Arithmetic and Consequences

2. Direct Methods for (Square) Linear Systems of Equations
   2.1 Introduction: Linear Systems of Equations
   2.3 Gaussian Elimination
   2.6 Exploiting Structure when Solving Linear Systems
   2.7 Sparse Linear Systems

3. Direct Methods for Linear Least Squares Problems
   3.1 Least Squares Solution Concepts
   3.2 Normal Equation Methods
   3.3 Orthogonal Transformation Methods
     3.3.1 Transformation Idea
     3.3.2 Orthogonal/Unitary Matrices
     3.3.3 QR-Decomposition
     3.3.4 QR-Based Solver for Linear Least Squares Problems
   3.4 Singular Value Decomposition

4. Filtering Algorithms
   4.1 Filters and Convolutions
   4.2 Discrete Fourier Transform (DFT)
   4.3 Fast Fourier Transform (FFT)

5. Machine Learning of One-Dimensional Data
   (Data Interpolation and Data Fitting in 1D)
   5.1 Abstract Interpolation (AI)
   5.2 Global Polynomial Interpolation

8. Iterative Methods for Non-Linear Systems of Equations
   8.1 Introduction
   8.2 Iterative Methods
   8.3 Fixed-Point Iterations
   8.4 Finding Zeros of Scalar Functions
   8.5 Newton’s Method in R^n
   8.6. Quasi-Newton Method

## Lecture notes

Lecture materials (PDF documents and codes) will be made available to the participants through the course web page and online repositories. Access information will be communicated in the beginning of the course.

## Literature

- M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

## Prerequisites / notice

The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves, in case they do not know it already.

## Competencies

- **Subject-specific Competencies**: Concepts and Theories assessed
  - Techniques and Technologies assessed
- **Method-specific Competencies**: Analytical Competencies assessed
  - Decision-making fostered
  - Problem-solving assessed
  - Project Management fostered

## Core Courses

### Major: Information and Data Processing

#### Visual Computing

- **Number**: 252-0206-00L
- **Title**: Visual Computing
- **Type**: O
- **ECTS**: 8 credits
- **Hours**: 4V+3U
- **Lecturers**: M. Gross, M. Pollefeys

**Abstract**

This course acquaints students with core knowledge in computer graphics, image processing, multimedia and computer vision. Topics include: Graphics pipeline, perception and camera models, transformation, shading, global illumination, texturing, sampling, filtering, image representations, image and video compression, edge detection and optical flow. The course forms a basis for the specialization track Visual Computing of the CS master program at ETH.

**Objective**

Course topics will include: Graphics pipeline, perception and color models, camera models, transformations and projection, projections, lighting, shading, global illumination, texturing, sampling theorem, Fourier transforms, image representations, convolution, linear filtering, diffusion, nonlinear filtering, edge detection, optical flow, image and video compression.

In theoretical and practical homework assignments students will learn to apply and implement the presented concepts and algorithms.

**Lecture notes**

A scriptum will be handed out for a part of the course. Copies of the slides will be available for download. We will also provide a detailed list of references and textbooks.

**Literature**


#### Human Computer Interaction

- **Number**: 252-3110-00L
- **Title**: Human Computer Interaction
- **Type**: O
- **ECTS**: 8 credits
- **Hours**: 3V+2U+2A
- **Lecturers**: C. Holz
Abstract
The course provides an introduction to the field of human-computer interaction, emphasizing the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyze the user experience and shown how these can inform the design of new interfaces, systems, and technologies.

Objective
The goal of the course is that students should understand the principles of user-centered design and be able to apply these in practice. As well as understanding the basic notions of Computational Design in a HCI context.

Content
The course will introduce students to several methods of analyzing the user experience, showing how these can be used at different stages of system development from requirements analysis through to usability testing.

Students will gain experience of designing and carrying out user studies as well as analyzing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

>>> Major: Theoretical Computer Science

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<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>252-0209-00L</td>
<td>Algorithms, Probability, and Computing</td>
<td>O</td>
<td>8 credits</td>
<td>4V+2U+1A</td>
<td>B. Gärtner, R. Kyang, A. Steger, D. Steurer</td>
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</tbody>
</table>

Abstract
Advanced design and analysis methods for algorithms and data structures: Random(ized) Search Trees, Point Location, Minimum Cut, Linear Programming, Randomized Algebraic Algorithms (matchings), Probabilistically Checkable Proofs (introduction).

Objective
Studying and understanding of fundamental advanced concepts in algorithms, data structures and complexity theory.

Literature

>>> Major: Systems and Software Engineering

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<th>Number</th>
<th>Title</th>
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<td>252-0210-00L</td>
<td>Compiler Design</td>
<td>O</td>
<td>8 credits</td>
<td>4V+3U</td>
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Abstract
This course uses compilers as examples to expose students to modern software development techniques. Tentative topics include: compiler organization; lexical analysis; top-down and bottom-up parsing; symbol tables; semantic analysis; code generation; local and global optimization; register allocation; automatic memory management.

Objective
Learn principles of compiler design; gain practical experience designing and implementing a medium-scale software system.

Prerequisites / notice
Prerequisites:
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Social Competencies
Communication
Cooperation and Teamwork
Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Literature

252-0217-00L Computer Systems

Abstract
This course is about real computer systems, and the principles on which they are designed and built. We cover both modern OSes and the large-scale distributed systems that power today's online services. We illustrate the ideas with real-world examples, but emphasize common theoretical results, practical tradeoffs, and design principles that apply across many different scales and technologies.

Objective
The objective of the course is for students to understand the theoretical principles, practical considerations, performance tradeoffs, and engineering techniques on which the software underpinning almost all modern computer systems is based, ranging from single embedded systems-on-chip in mobile phones to large-scale geo-replicated groups of datacenters.

By the end of the course, students should be able to reason about highly complex, real, operational software systems, applying concepts such as hierarchy, modularity, consistency, durability, availability, fault-tolerance, and replication.
This course subsumes the topics of both "operating systems" and "distributed systems" into a single coherent picture (reflecting the reality that these disciplines are highly converged). The focus is on system software: the foundations of modern computer systems from mobile phones to the large-scale geo-replicated data centers on which Internet companies like Amazon, Facebook, Google, and Microsoft are based.

We will cover a range of topics, such as: scheduling, network protocol stacks, multiplexing and demultiplexing, operating system structure, inter-process communication, memory management, file systems, naming, dataflow, data storage, persistence, and durability, computer systems performance, remove procedure call, consensus and agreement, fault tolerance, physical and logical clocks, virtualization, and blockchains.

The format of the course is a set of about 25 topics, each covered in a lecture. A script will be published online ahead of each lecture, and the latter will consist of an interactive elaboration of the material in the script. There is no book for the course, but we will refer to books and research papers throughout to provide additional background and explanation.

We will assume knowledge of the "Systems Programming" and "Computer Networks" courses (or equivalent), and their prerequisites, and build upon them.

### Electives

Students may also choose courses from the Master's program in Computer Science. It is their responsibility to make sure that they meet the requirements and conditions for these courses.

#### Number Title Type ECTS Hours Lecturers

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<th>Number</th>
<th>Title</th>
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<tr>
<td>227-0085-59L</td>
<td>Hands-On Deep Learning</td>
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<td>2</td>
<td>2P</td>
<td>R. Wattenhofer</td>
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<td>Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.</td>
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<td><strong>Abstract</strong></td>
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<td>This lab introduces deep learning through the PyTorch framework in a series of hands-on exercises, exploring topics in computer vision, natural language processing, audio processing, graph neural networks, and representation learning.</td>
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<td>This P&amp;S introduces deep learning through the PyTorch framework in a series of hands-on examples, exploring topics in computer vision, natural language processing, graph neural networks, and representation learning. With the objective to expose students to both common and cutting-edge neural architectures and to build intuition about their inner working by the means of examples. Students learn about various network structures as building blocks and use them to solve worked examples and course challenges. After attending this course, students will be familiar with multi-layer perceptrons, convolutional neural networks, recurrent neural networks, transformer encoders, graph convolutional/isomorphism/attention networks, and autoencoders.</td>
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<td><strong>Content</strong></td>
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<td>For information about the lab, please visit <a href="https://disco.ethz.ch/courses/hs24/hodl/">https://disco.ethz.ch/courses/hs24/hodl/</a></td>
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<td><strong>Lecture notes</strong></td>
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<td>Python Notebooks will be distributed to students before every session.</td>
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<td><strong>Competencies</strong></td>
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<td>227-0124-00L</td>
<td>Embedded Systems</td>
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<td>M. Magno</td>
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</table>
An embedded system is a combination of hardware and software, either fixed in function or programmable, that is designed for a specific application scenario or for a specific task within a larger system. They are part of industrial machines such as agricultural and manufacturing equipment, automotive systems, medical equipment, household appliances, sensor networks, and the Internet of Things.

**Objective**

Understanding the specific requirements and problems that arise in embedded system applications.

Understanding the hardware structure of a microcontroller and an embedded system; memory architecture and memory map, internal and external peripherals, low-power and low-energy design as well as instruction sets and computational accelerators.

Understanding the firmware structure of a microcontroller and an embedded system; low-level instruction set, hardware-software interfaces, communication between components, embedded real-time operating systems, real-time scheduling, shared resources, low-power, and low-energy programming as well as computational accelerators.

Using formal models and methods for designing and optimizing embedded systems.

Gaining experience with practical applications of the C programming language, embedded real-time operating systems, and debug functionalities of the associated design environment to design, implement, and verify embedded firmware.

Through project-based activities, students will gain substantial experience in applying the C programming language in the context of embedded systems. Projects will involve developing and implementing firmware, utilizing embedded real-time operating systems, and exploring the debugging functionalities within design environments. This hands-on approach aims to bridge the gap between theoretical knowledge and practical application, allowing students to experience the full lifecycle of embedded system development from design to implementation and verification.

This lecture focuses on the design of embedded systems using formal models and methods.

Besides the theoretical lecture, the course contains laboratory sessions where students transfer the learned theoretical aspects into praxis by programming a microcontroller and interfacing it with sensors and actuators. Students will be exposed to a commercial microcontroller, and the development board extend with a custom-designed embedded systems educational platform.

Specifically, the following topics will be covered in the course: hardware and software structures of embedded systems, low-level instruction set, memory architecture and memory map, peripherals, hardware-software interfaces, communication between components, firmware design methodologies, firmware design using the C programming language, embedded real-time operating systems, real-time scheduling, shared resources, low-power, and low-energy designs as well as computational accelerators.

Lecture material, publications, exercise sheets, and laboratory documentation will be available on the course's Moodle page.

**Literature**


**Prerequisites / notice**

Prerequisites: C programming, circuit theory, digital logic, binary number representations.

Recommended: basic knowledge of assembly programming and computer architecture.

**Competencies**

Subject-specific Competencies: Concepts and Theories assessed
Methods and Technologies assessed

Method-specific Competencies:
- Decision-making fostered
- Problem-solving fostered
- Project Management fostered

Social Competencies:
- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies:
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

**Prerequisites / notice**

Script and exercises sheets.

Basis of computer architecture.

**Objective**

This lecture gives an overview of the requirements and the architecture of parallel computer systems, performance, reliability and costs.

Understand the function, the design and the performance modeling of parallel computer systems.

The lecture “Applied Computer Architecture” gives technical and corporate insights in innovative Computer Systems/Architectures (CPU, GPU programming, microprocessors) and their real implementations and applications. Often the designs have to deal with technical limits. Which computer architecture allows the control of the over 1000 magnets at the Swiss Light Source (SLS) at the PSI?

Which architecture is behind the alarm center of the Swiss Railway (SBB)?

Which computer architectures are applied for driver assistance systems?

Which computer architecture is hidden behind a professional digital audio mixing desk?

How can data streams of about 30 TB/s, produced by a protone accelerator, be processed in real time?

Can the weather forecast also be processed with GPUs?

How could a fast trading system be set up for the stock exchange?

How can a good computer architecture be found?

Which are the driving factors in successful computer architecture design?

**Lecture notes**

Script and exercises sheets.

**Competencies**

Concepts and Theories assessed
Techniques and Technologies assessed

**Prerequisites / notice**

Basis of computer architecture.
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

The objective of this introductory course is to introduce the monoculars of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transmission and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the brain can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.

The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own add-on mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator. We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.

The course material will be made available by the lecturer.

The Java 802 protocol emulator "JEmula802" from https://bitbucket.org/lfield/jemula802

IEEE 802.11 Wireless LAN (Wi-Fi)
IEEE 802.15 Wireless PAN (ZigBee & Bluetooth)
Mobile Computing Algorithm Basics: Control and Game Theory
Visible Light Communication
Audio Communication
Cellular Networking Basics (LTE, 5G, Internet-of-Things)
Mobile Computing for Automated Medicine Delivery
Cognitive Radio, Delay Tolerant Networking, Radio Spectrum Sharing

Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required).

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

227-1037-00L Introduction to Neuroinformatics

Abstract

Objective

Content

Prerequisites / notice

252-0293-00L Wireless Networking and Mobile Computing

Abstract

Objective

Content

Lecture notes

Literature

Prerequisites / notice

252-2810-00L Fundamentals of Web Engineering

Abstract

Objective

Content

Prerequisites / notice
Abstract
Contemporary web development utilizes a technology stack that spans from back-ends to front-ends, and includes virtual server environments, document databases, back-end and front-end programming, and UI/UX design. The depth of this stack fosters separation of concern and reuse, but also amounts to a steep learning curve.

Objective
This course introduces both theoretical and applied aspects of web engineering. It covers:
- DOM, CSS, Typescript
- Fronted and backend frameworks
- Client-server communication
- Interaction design, visualization and narrative storytelling
- Security for in the context of web engineering
- Desktop applications using web development techniques

Content
The course has two main objectives:
- Obtain an end-to-end (both, theoretical and practical) understanding of the foundations of web engineering.
- Be able to apply these techniques in practice.

While the lecture will provide the theoretical foundations for the various aspects of web engineering, the students will apply those techniques in project work that will span over the whole semester - involving different aspects of web engineering.

Lecture notes
The lecture slides are available for download on the course page.

Prerequisites / notice
To contact us please us the following email: web-foundations@ethz.ch

Students should be familiar with the basics of a programming language (C, C++, Python, Java, Javascript, Typescript). The course will not teach basics of programming.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Self-awareness and Self-reflection assessed

402-0209-00L Quantum Physics for Non-Physicists W 6 credits 3V+2U P. Kammerlander

Abstract
This is an introduction to the physics of quantum mechanics following an information-theoretical approach. We start from the basic postulates, study the behaviour of quantum systems from a single spin to entangled particles in space, and connect the learnings to groundbreaking experiments from the past and the present. This course is well-suited for students with little background in physics.

Objective
This course teaches the basics of quantum physics, and complements courses in quantum computation and information theory. Students are equipped with tools to tackle complex quantum mechanical problems and foundational questions. The course covers approximately the same content as QM1, but from an information-driven perspective.

Content
Quantum formalism, from qubits to particles in space; Time and dynamics for quantum systems; Problems in 1D; Uncertainty and open systems; Spin; Problems in 3D; Non-locality and foundational aspects of quantum theory

Lecture notes
Lecture notes will be provided.

Literature
Quantum Processes, Systems, and Information, by Benjamin Schumacher and Michael Westmoreland, available at
https://www.cambridge.org/core/books/quantum-processes-systems-and-information/4E459E64E1EE7121CA2321435FAECC8A

Prerequisites / notice
This course is aimed at non-physicists, and in particular at students with a background in computer science, mathematics or engineering. Basic linear algebra and calculus knowledge is required (equivalent to first-year courses). Physics knowledge is not required. Physicists and students from a different background than outlined above are welcome at their own risk.

Note that while we follow an information-theoretical approach, this is not a course on quantum information theory or quantum computing. It therefore complements those courses offered at ETH Zurich.

This course can be taken in parallel to Quantum Information Processing I & II.
The main goals of this seminar are 1) learning how to read and understand a recent research paper in computer science; and 2) learning about the technical content of this course falls into the general area of software engineering but will vary from semester to semester.

Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like dependency parsing and their derivation in a unified algebraic framework. The course is for those interested in computer architecture. Registered students are expected to attend every lecture, participate in the discussion, and create a synthesis report at the end of the course.

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

In this seminar course, we will cover fundamental and cutting-edge research papers in computer architecture. The course will consist of multiple components that are aimed at improving students' technical skills in computer architecture, critical thinking and analysis on computer architecture concepts, as well as technical presentation of concepts and papers in both spoken and written forms.

Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous presentation and discussion of selected papers during lectures and a written report delivered by each student at the end of the semester. This course is for those interested in computer architecture. Registered students are expected to attend every lecture, participate in the discussion, and create a synthesis report at the end of the course.

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Students should (1) have done very well in Digital Design and Computer Architecture, Digital Circuits or a similar course and (2) show a genuine interest in Computer Architecture.

See https://safari.ethz.ch/architecture_seminar for past examples.

Links to past course materials, including the synthesis report assignment, can be found in this page: https://safari.ethz.ch/architecture_seminar

Digital Design and Computer Architecture OR Digital Circuits / Computer Engineering

Students should (1) have done very well in Digital Design and Computer Architecture, Digital Circuits or a similar course and (2) show a genuine interest in Computer Architecture.

The main objectives of this seminar are 1) learning how to read and understand a recent research paper in computer science; and 2) learning how to present a technical topic in computer science to an audience of peers.
Seminar on Machine Learning Systems
W 2 credits 2S A. Klimovic
252-3400-00L
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar covers core concepts and ideas in the general area of machine learning systems, ranging from distributed and federated learning systems, DevOps systems for ML, life cycle and data management systems for ML, etc.

Objective
The seminar covers core concepts and ideas in the general area of machine learning systems, ranging from distributed and federated learning systems, DevOps systems for ML, life cycle and data management systems for MLs, etc. The focus will be to cover fundamental ideas on ML systems, with an emphasis on software systems and platforms.

Content
The seminar will consist of student presentations based on a list of papers that will be provided at the beginning of the course. Presentations will be done in teams. Presentations will be arranged in slots of 30 minutes talk plus 15 minutes questions. Grades will be assigned based on quality of the presentation, coverage of the topic including material not in the original papers, participation during the seminar, and ability to understand, present, and criticize the underlying technology.

Case Studies from Practice Seminar
W 4 credits 2S M. Brandis
252-3811-00L
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
Participants will learn how to analyze and solve IT problems in practice in a systematic way, present findings to decision bodies, and defend their conclusions.

Objective
Participants understand the different viewpoints for IT-decisions in practice, including technical and business aspects, can effectively analyze IT questions from the different viewpoints and facilitate decision making.

Content
Participants learn how to systematically approach an IT problem in practice. They work in groups of three to solve a case from a participating company in depth, studying provided materials, searching for additional information, analyzing all in depth, interviewing members from the company or discussing findings with them to obtain further insights, and presenting and defending their conclusion to company representatives, the lecturer, and all other participants of the seminar. Participants also learn how to challenge presentations from other teams, and obtain an overview of learnings from the cases other teams worked on.

Machine Learning Seminar
W 2 credits 2S V. Boeva, E. Krymova, L. Salamanca Miño
252-4811-00L
The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
Seminal and recent papers in machine learning are presented and discussed.

Objective
The seminar familiarizes students with advanced and recent ideas in machine learning. Original articles have to be presented, contextualized, and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper.

Content
The seminar will cover a number of recent papers which have emerged as important contributions in the machine learning research community. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications.

Literature
The papers will be presented and allocated in the first session of the seminar.
Seminar on Game Technology

The Seminar on Game Technology offers an in-depth exploration of video games as a significant cultural asset and a major force in

H. Metzmacher

The objectives of this seminar are twofold: (1) to learn about recent developments in the area of game technology at the intersection of computer graphics, computer vision, human-computer interaction, virtual and augmented reality, natural language processing, and machine learning and (2) to improve the presentation and critical analysis skills.

The seminar aims to introduce students to the latest research and innovations in game technology. It also provides an opportunity to explore the foundational algorithms that underpin classic games still enjoyed today. Additionally, the seminar will cover emerging topics that, while currently peripheral to game technology, hold the potential to inspire new and creative gaming concepts in the near future.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td>Self-presentation and Social Influence</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<td>Self-direction and Self-management</td>
<td>fostered</td>
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</table>

Prerequisites / notice

Basic knowledge of machine learning as taught in undergraduate courses such as "252-0220-00 Introduction to Machine Learning" are required.

Minor Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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Prerequisites / notice

Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.
The course is about digital innovation towards a circular economy in the built environment. How can we bring together two worlds that are often too distinct: low-impact construction and digital innovation? Bringing digital tools already used in other sectors into the construction sector, students will learn about circular construction (e.g., reuse of materials) through hands-on learning practices.

By the end of this course, students will be able to use augmented computational design enabling circular construction, with a view to environmental implications. They will be able to assess the challenges and opportunities of low-carbon, circular construction and evaluate possible solutions using digital technologies to enable a circular built environment (more specifically, with reused building materials). To achieve this, they need to be able to do the following:

1. Apply circular principles using recovered building materials.
2. Compare different digital technologies applied in circular construction (e.g., LiDAR scanning, drone imagery, photogrammetry, computational design, AI, computer vision, XR, LCA tools etc.).
3. Understand the potential and limitations of AI for circular construction, e.g. use machine learning to detect and digitize materials (computer vision) or to support creativity in the early design phases of circular construction (generative AI).
4. Communicate the importance and urgency of circular construction.
5. Assess the environmental impact implications of their design and technology decisions through a preliminary Life Cycle Assessment (LCA).

Students will receive an introduction to circular principles by experts from the building industry and visit of (de-)construction sites where circular construction is exemplified. They will explore how to use digital technologies such as LiDAR scanning, photogrammetry, scan-to-BIM, computer vision, computational design, digital fabrication, blockchain technology and learn about the design implications using reclaimed building materials. This course is meant as an overview/introduction of many digital technologies that could be useful for circularity and gives the tools to students to further study the technologies they are most interested in on their own. Creativity in writing, filmmaking, design, construction, etc. is expected from the students. This course will give the tools to students to learn more on LCA if they wish to deepen their knowledge further.

Lecture notes
Language: English
Courses are on Tuesday afternoons in Kunsthalle or a room at ETH, but also require out-of-the-semester work and significant homework and site visits outside of class hours.

Literature

Prerequisites / notice
Digitalisation and Construction. Flexibility: This is a hands-on course, where students explore digital technologies and opportunities/challenges of reuse. Flexibility (e.g. adapting to unforeseen circumstances), responsibility (e.g. arriving on time for safety briefing), and spontaneity (e.g. finding innovative solutions) is expected from the students to adapt to the contingencies from demolition and construction sites with reused materials. The course is mandatory for MIBS students. If you are a first year MIBS student, please do not apply, you are automatically accepted. All other students from other departments should apply. Please only register for the course if you really intend to participate on all course dates (see course catalog). Please only register for the course if you are willing to send us a letter of motivation and really intend to participate; otherwise, you will deprive someone else of a place. All non-MIBS students who register go on a waiting list until 11.09.2024. To register:

1. Enroll before 05.09.2024.
2. Send a short letter of motivation (max. 300 words) and a 1-page CV to cea-course@ibi.baug.ethz.ch by 05.09.2024.

Collaborators: Kunsthalle Zurich, ETH AI Center, Design++

Digital Creativity for Circular Construction

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<td>Decision-making</td>
<td>Cooperate and Teamwork</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td>Problem-solving</td>
<td>Project Management</td>
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101-0531-00L

Digital Creativity for Circular Construction
All students who register go on a waiting list until 11.09.2024. To register:
1. Enroll before 05.09.2024
2. Send a short motivation letter (max. 300 words) and a 1-page CV to cea-course@ibi.baug.ethz.ch by 05.09.2024
3. MIBS students: This course is mandatory and there is no need to send your application documents

Please only register for the course if you really intend to participate on all course dates (see course catalog), otherwise, you will deprive someone else of a place.

Abstract
The course is about digital innovation towards a circular economy in the built environment. How can we bring together two worlds that are often too distinct: low-impact construction and digital innovation? Bringing digital tools already used in other sectors into the construction sector, students will learn about circular construction (e.g., reuse of materials) through hands-on learning practices.

In the fall semester 2024 we will focus on applying artificial intelligence (AI) and extended reality (XR) to the circular design workflow and.

Please only register for the course if you really intend to participate on all course dates (see course catalog), otherwise, you will deprive someone else of a place.

Objective
In the fall semester 2024 we will focus on applying artificial intelligence (AI) and extended reality (XR) to the circular design workflow and.

The course will be taught at the Kunsthalle Zurich as part of an exhibition.

By the end of this course, students will be able to use augmented computational design enabling circular construction, with a view to environmental implications. They will be able to assess the challenges and opportunities of low-carbon, circular construction and evaluate possible solutions using digital technologies to enable a circular built environment (more specifically, with reused building materials). To achieve this, they need to be able to do the following:

1. Apply circular principles using recovered building materials.
2. Compare different digital technologies applied in circular construction (e.g., LiDAR scanning, drone imagery, photogrammetry, computational design, AI, computer vision, XR, LCA tools etc.).
3. Understand the potential and limitations of AI for circular construction, e.g. use machine learning to detect and digitize materials (computer vision) or to support creativity in the early design phases of circular construction (generative AI).
4. Communicate the importance and urgency of circular construction.
5. Assess the environmental impact implications of their design and technology decisions through a preliminary Life Cycle Assessment (LCA).

Content
Students will receive an introduction to circular principles by experts from the building industry and visit of (de-)construction sites where circular construction is exemplified. They will explore how to use digital technologies such as LiDAR scanning, photogrammetry, scan-to-BIM, computer vision, computational design, digital fabrication, blockchain technology and learn about the design implications using reclaimed building materials. This course is meant as an overview/introduction of many digital technologies that could be useful for circularity and gives the tools to students to further study the technologies they are most interested in on their own. Creativity in writing, filmmaking, design, construction, etc. is expected from the students. This course will give the tools to students to learn more on LCA if they wish to deepen their knowledge further.

Lecture notes
Language: English
Courses are on Tuesday afternoons in Kunsthalle or a room at ETH, but also require out-of-the-semester work and significant homework and site visits outside of class hours.

Literature

Prerequisites / notice
Digitalisation and Construction. Flexibility: This is a hands-on course, where students explore digital technologies and opportunities/challenges of reuse. Flexibility (e.g. adapting to unforeseen circumstances), responsibility (e.g. arriving on time for safety briefing), and spontaneity (e.g. finding innovative solutions) is expected from the students to adapt to the contingencies from demolition and construction sites with reused materials. The course is mandatory for MIBS students. If you are a first year MIBS student, please do not apply, you are automatically accepted. All other students from other departments should apply. Please only register for the course if you really intend to participate on all course dates (see course catalog). Please only register for the course if you are willing to send us a letter of motivation and really intend to participate; otherwise, you will deprive someone else of a place. All non-MIBS students who register go onto a waiting list until 11.09.2024 and up to 25 of them will be selected by the lecturer.

To register:
1. Enroll before 05.09.2024.
2. Send a short letter of motivation (max. 300 words) and a 1-page CV to cea-course@ibi.baug.ethz.ch by 05.09.2024.

Collaborators: Kunsthalle Zürich, ETH AI Center, Design++
In this course, we will concentrate on systems that can be modeled by Ordinary Differential Equations (ODEs), and that satisfy certain other technical conditions, such as linearity and time-invariance. In addition, we will focus on systems with a Single Input and a Single Output (SISO).

The main objective is to learn how to design the control inputs in such a way that the measured outputs have some desirable properties. For example, for an advanced driver assistance system, how to control acceleration so that the speed remains constant, and how to control the steering angle so that the car remains in the center of the lane.

In order to pursue this objective, the course is organized into three main parts:

1) Modeling: learn how to represent a dynamic control system in such a way that it can be treated effectively using computational and mathematical tools. This will include learning how to use computer tools like Matlab to simulate dynamic control systems.

2) Analysis: understand the basic characteristics of a system, such as its (internal and external) stability, performance, and robustness, and how the input affects the output. We will also learn to analyze systems obtained as interconnections (e.g., feedback) of two or more other systems. In particular, we will focus on tools that allow to understand how a system will behave under feedback control (i.e., closed-loop behavior), based only on its open-loop behavior.

3) Synthesis: the last part of the course will concentrate on how to design feedback control laws, in order to change the behavior of the system in a desirable way.

In this course, we will concentrate on systems that can be modeled by Ordinary Differential Equations (ODEs), and that satisfy certain other technical conditions, such as linearity and time-invariance. In addition, we will focus on systems with a Single Input and a Single Output (SISO).

This will allow us to use "classical control" tools that are very powerful and easy to use (i.e., mostly graphical), and which are really laying the foundation of any follow-up work on more challenging control problems.

In addition to paper-and-pencil techniques, we will leverage modern computational tools for control design, such as Matlab.

For students in the bachelor's degree programme in mechanical engineering: Precondition for this course unit are passed first year examination blocks A and B.
Scientists

Abstract
The course provides an introduction into stochastic methods that are applicable for the description, treatment, and modeling of systems that are subject to uncertainties or that respond to parameter changes in a chaotic manner. Corresponding systems may arise in fluid dynamics, structural mechanics, biology, electrical engineering as well as other areas.

Objective
By the end of the course you will be familiar with a range of mathematical/statistical tools that enable a quantitative treatment of problems that involve uncertainties.

Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Itô calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation
- Kalman filters (classical and ensemble-based)
- Statistical tests for means and goodness-of-fit

Lecture notes
Detailed lecture notes will be provided.

Literature
Some textbooks related to the material covered in the course:

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Electrical Engineering I

Abstract
Basic course in electrical engineering with the following topics: Concepts of voltage and currents; Analyses of dc and ac networks; Series and parallel resistive circuits, circuits including capacitors and inductors; Kirchhoff's laws and other network theorems; Transient responses; Basics of electrical and magnetic fields;

Objective
Understanding of the basic concepts in electrical engineering with focus on network theory. The successful student knows the basic components of electrical circuits and the network theorems after attending the course.

Content
Diese Vorlesung vermittelt Grundlagenkenntnisse im Fachgebiet Elektrotechnik. Ausgehend von den grundlegenden Konzepten der Spannung und des Stroms wird die Analyse von Netzwerken bei Gleich- und Wechselstrom behandelt. Dabei werden folgende Themen behandelt:

Kapitel 1 Das elektrostatische Feld
Kapitel 2 Das stationäre elektrische Strömungsfeld
Kapitel 3 Einfache elektrische Netzwerke
Kapitel 4 Halbleiterbauelemente (Dioden, der Transistor)
Kapitel 5 Das stationäre Magnetfeld
Kapitel 6 Das zeitlich veränderliche elektromagnetische Feld
Kapitel 7 Der Übergang zu den zeitabhängigen Strom- und Spannungsformen
Kapitel 8 Wechselspannung und Wechselstrom

Lecture notes
Die Vorlesungsfolien werden auf Moodle bereitgestellt.

Literature
Als ausführliches Skript wird das Buch "Manfred Albach. Elektrotechnik, Person Verlag, Ausgabe vom 1.8.2011" empfohlen.

Prerequisites / notice
Für students in the bachelor's degree programme in mechanical engineering:
Precondition for this course unit are passed first year examination blocks A and B.

VLSI 1: HDL Based Design for FPGAs

Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:

- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Aneceu diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

**Lecture notes**

- Textbook and all further documents in English.

**Literature**


**Prerequisites / notice**

- Examinations: In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:

https://iis-students.ee.ethz.ch/lectures/vlsi-i/

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**227-0731-00L Power Market I - Portfolio and Risk Management**

<table>
<thead>
<tr>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>D. Reichelt, G. A. Koeppel</th>
</tr>
</thead>
</table>

**Abstract**

- Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

**Objective**


**Content**

1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX
2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions
3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   2.8. Risk Management 3 (enterprise wide)
4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

**Lecture notes**

- Handouts of the lecture

**Prerequisites / notice**

- Case studies and ML exercise for Power Market can give bonus points for the exam. Guest speakers for specific topics.

**Competencies**

- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Decision-making assessed, Media and Digital Technologies assessed, Problem-solving assessed, Project Management assessed
- Social Competencies: Communication fostered, Cooperation and Teamwork fostered
- Personal Competencies: Adaptability and Flexibility fostered, Creative Thinking fostered, Critical Thinking fostered
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course covers the fundamentals of numerical methods such as coupled electromagnetic-mechanical and electromagnetic-thermal simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

The “Training for Programming Coaches” course is designed to prepare students for the role of a teaching assistant in an introductory programming course. The focus is on developing constructive coaching skills, particularly in giving effective feedback and competently conducting project presentations.

In this course, teaching assistants (TAs) will learn...

1. Understanding the role of teaching assistants:
   - recognising the responsibilities and expectations of teaching assistants.

2. Develop communication skills:
   - Using effective communication techniques.
   - Empathic listening and appropriate response to students' questions and concerns.

3. Giving feedback:
   - Understanding the principles of effective feedback.
   - Avoiding common mistakes and misunderstandings when giving feedback.

4. Accepting project presentations:
   - Develop criteria for evaluating and assessing project presentations.
   - Apply objective assessment techniques to ensure fairness and consistency.
   - Methods to support and develop students' presentation skills.

5. Conflict resolution:
   - recognising and addressing potential conflict situations between students and teaching assistants.
   - Developing strategies for de-escalation and conflict resolution.

6. Didactic skills:
   - Teaching basic didactic principles to support the learning process of students.
   - Designing learning experiences and using tools that promote student understanding.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course covers the fundamentals of numerical methods such as coupled electromagnetic-mechanical and electromagnetic-thermal simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Discovering Management does not take place this semester.

Entry level course in management for BSc, MSc and PHD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Excercises) 351-0778-01.
Objective
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1) broaden understanding of management principles and frameworks
2) advance insights into the sources of corporate and entrepreneurial success
3) develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

Content
The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

351-0778-01L Discovering Management (Pitch) W 1 credit 1U B. Clarysse, L. P. T. Vandeweghe

Abstract
Does not take place this semester.

Complementary exercises for the module Discovering Management.

Prerequisite: Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.

Objective
The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Content
The exercise consists of delivering and submitting a "pitch" with a clear recommendation for one of the selected cases amongst those seen in Discovering Management, using your insights from Discovering Management, and an extra session on pitching.

Students have the option to either do this alone or in a group of two students.

Literature
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

351-1109-00L Introduction to Microeconomics W 3 credits 2G M. Wörter, M. Beck

GESS (Science in Perspective):
This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.
System theory sees the economy as a complex adaptive system. Economic Dynamics and Complexity

Economic Dynamics and Complexity

**363-0541-00L**

**Objective**

What causes economic business cycles? How are limited resources, competition, and cooperation reflected in growth dynamics? To answer such questions, we combine macroeconomic models and methods of nonlinear dynamics. We study the role of bifurcations and control parameters for dynamic stability. Feedback cycles and coupled dynamics are reasons for limited predictability, instability and chaos.

**Content**

System theory sees the economy as a complex adaptive system. What does this mean for economic modeling? We focus on two sources of complexity: (a) nonlinear dynamics, which is captured in this course, “Economic Dynamics and Complexity” and (b) collective interactions, which is captured in the course “Agent-Based Modeling of Economic Systems” (in Spring).

Our approach to economic dynamics combines insights from different disciplines: macroeconomics studying business cycles and growth, system dynamics rooted general system theory and cybernetics, and nonlinear dynamics used applied mathematics.

We start with a comparison of different modeling approaches, to highlight the problems and challenges of system modeling. The subsequent lectures then introduce different one- and two-dimensional nonlinear models with applications in economics, such as models of supply and demand, business cycles, growth and competition.

Emphasis is on the formal analysis of these models using methods from applied mathematics and tools for solving coupled differential equations.

Weekly self-study tasks are used to apply the concepts introduced in the lectures. We practice how to solve nonlinear models formally and numerically and how to interpret the results.

**Lecture notes**

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

**Prerequisites / notice**

Students should be familiar with nonlinear differential equations and should have basic programming skills. All necessary details to solve nonlinear models will be provided in the course. The course will not build on mathematical proofs, optimization, statistics, efficient numerical computation and other specialized skills.

**Competencies**

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making

- Media and Digital Technologies
- Problem-solving

- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**363-1082-00L**

**Objective**

Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are...
required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 25 September 2024 and apply to Robin De Cock: Robin.DeCock@uantwerpen.be.

Abstract
This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective
Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs.
2. The students can be from business or science & technology.
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea.

Content
The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders' agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Lecture notes
Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

Literature
Book
Sethi, A. “From Science to Startup”
ISBN 978-3-319-30422-9

Prerequisites / notice
This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

Competencies

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<tr>
<th>363-1163-00L</th>
<th>Developing Digital Biomarkers</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>F. Da Conceição Barata</th>
</tr>
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<tbody>
<tr>
<td>Particularly suitable for students with a technical background who are interested in healthcare.</td>
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Abstract

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

Objective

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course, we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:
- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer-centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.
Objective

The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

Content

1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)

2.) Quasilinear first order PDEs
   - Solution with the method of characteristics
   - Conservation laws

3.) Hyperbolic PDEs
   - wave equation
   - d'Alembert formula in (1+1)-dimensions
   - method of separation of variables

4.) Parabolic PDEs
   - heat equation
   - maximum principle
   - method of separation of variables

5.) Elliptic PDEs
   - Laplace equation
   - maximum principle
   - method of separation of variables
   - variational method

Literature


Prerequisites / notice

Prerequisites: Analysis I and II, Fourier series (Complex Analysis)

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

401-0625-01L Applied Analysis of Variance and Experimental Design W 5 credits 2V+1U L. Meier

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making

Personal Competencies
- Critical Thinking

401-3913-01L Mathematical Foundations for Finance W 4 credits 3V+2U D. Possamai

Abstract
First introduction to main modelling ideas and mathematical tools from mathematical finance

Objective
This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Content
Topics to be covered include
- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

Lecture notes
See information on course homepage

Prerequisites / notice
Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitstheorie".) For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary

Physics I


Analytical Competencies

Decision-making

Problem-solving

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

J. Stelling

401-4623-00L Time Series Analysis W 4 credits 2G F. Balabdaoui

Abstract

The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective

The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.

Content

This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:

Stationarity

Autocorrelation

Trend estimation

Elimination of seasonality

Spectral analysis, spectral densities

Forecasting

ARMA, ARIMA, Introduction into GARCH models

Literature

The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

Prerequisites / notice

Basic knowledge in probability and statistics

401-7855-00L Computational Astrophysics (University of Zurich) W 6 credits 2V L. M. Mayer

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: AST245

Objective

Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes

Content

1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility

2. Large-N gravity calculation, collisionless N-body systems and their simulation

3. Fast Fourier Transform and spectral methods in general

4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters

5. Lagrangian Hydrodynamics: The SPH method

6. Resolution and instabilities in Hydrodynamics

7. Initial Conditions: Cosmological Simulations and Astrophysical Disks

8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

Literature

Galactic Dynamics (Binney & Tremaine, Princeton University Press),

Computer Simulation using Particles (Hockney & Eastwood CRC press),

Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

Prerequisites / notice

Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial

402-0809-00L Introduction to Computational Physics W 8 credits 2V+2U A. Adelmann

This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

Objective

Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

Content

Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

Lecture notes

Lecture notes and slides are available online and will be distributed if desired.

Literature

Lecture recommendations and references are included in the lecture notes.

Prerequisites / notice

Lecture and exercise lessons in English, exams in German or in English

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

402-1701-00L Physics I W 7 credits 4V+2U K. Ensslin

Abstract

This course gives a first introduction to Physics with an emphasis on classical mechanics.

Objective

Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.

636-0007-00L Computational Systems Biology W 6 credits 3V+2U J. Stelling

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modelling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.
Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

651-4241-00L 
Numerical Modelling I and II: Theory and Applications 
W 6 credits 
T. Gerya

Abstract
In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasise a hands-on learning approach rather than extensive theory.

Objective
The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.

Content
A provisional week-by-week schedule (subject to change) is as follows:

Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity with stream function/vorticity formulation.


Week 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


Week 14: Final project description for slab breakoff modeling.

GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

701-0071-00L 
Mathematics III: Systems Analysis W 4 credits 
2V+1U 
C. Brunner, R. Knutti, H. Wernli

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.
Lecture notes
Overhead slides will be made available through the course website.

Literature


Competencies

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Problem-solving

- **Personal Competencies**
  - Creative Thinking
  - Critical Thinking

Competencies

- **Subject-specific Competencies**
  - Reflect on their approach to teaching as well as their attitude towards teaching.
  - Understand the basics of teaching and learning in the context of their subject.
  - Consciously design the introduction of their course as well as the introduction of single teaching units.
  - Apply classroom assessment techniques as formative assessments to measure the current status of their students.
  - Develop a didactic concept according to the learning objectives.
  - Conduct interactive sequences as learning activities.
  - Give and get feedback from peers and self-reflect on their teaching practice.

- **Method-specific Competencies**
  - Feel confident to use methods for active learning scenarios in their classes.

- **Personal Competencies**
  - Feel confident to use methods for active learning scenarios in their classes.

Abstract
The course "Didactic Basics for Student Teaching Assistants" enhances Student Teaching Assistants (Student TAs) to develop knowledge, capability and confidence to effectively plan and teach courses and exercises. Participants get trained to think critically about students' learning and create learning situations in which students are actively engaged.

Objective
In this course Student Teaching Assistants will...

- Reflect on their approach to teaching as well as their attitude towards teaching.
- Understand the basics of teaching and learning in the context of their subject.
- Consciously design the introduction of their course as well as the introduction of single teaching units.
- Apply classroom assessment techniques as formative assessments to measure the current status of their students.
- Develop a didactic concept according to the learning objectives.
- Conduct interactive sequences as learning activities.
- Give and get feedback from peers and self-reflect on their teaching practice.
- Feel confident to use methods for active learning scenarios in their classes.

Content
The online course provides a range of relevant topics for developing teaching competencies of Student Teaching Assistants:

- Overview about how learning works. Based on these fundamentals of learning participants reflect on their role as Student TAs to feel comfortable in their new role as a teacher.
- Plan an own lesson by introducing a class and locate it in the larger topic (methods: portal and informative introduction).
- Develop learning activities in order to activate students (active learning methods).
- Giving and also getting feedback. The participants integrate this topic also in their lesson plan.

While working through the online course, Student TAs have the chance to reflect, exchange ideas with peers and plan their own teaching accordingly so that they feel confident in their role.

Prerequisites / notice
Self-paced online course with an online/faceto-face consolidation workshop.

Consolidation Workshops take place online or in presence (you have the choice). Dates will be released at the beginning of the new semester.

You need to choose one of the dates and you will find registration details and a deadline in the Moodle course.

Competencies

- **Method-specific Competencies**
  - Media and Digital Technologies
  - Communication

- **Social Competencies**
  - Cooperation and Teamwork

- **Personal Competencies**
  - Critical Thinking
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

Science in Perspective

- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-INFK

Language Courses

- see Science in Perspective: Language Courses ETH/UZH

Bachelor's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0500-00L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>10 credits</td>
<td>21D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
The Bachelor thesis is the final requirement of the BSc program and is supervised by one of the D-INFK professors. The thesis encourages students to show and produce a scientifically structured work.

Objective
In their BSc thesis students should demonstrate their ability to carry out independent, structured scientific work.

Prerequisites / notice
The supervisor of the thesis defines the task, start and end date. A written report will be prepared on the scientific studies carried out, followed by a final presentation. The thesis must be handed in within 6 months.

Computer Science Bachelor - Key for Type

- **O** Compulsory
- **W+** Eligible for credits and recommended
- **W** Eligible for credits
- **E-** Recommended, not eligible for credits
- **Z** Courses outside the curriculum
- **Dr** Suitable for doctorate

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## Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Computer Science TC

**Detailed information on the programme at:** [www.didaktischeausbildung.ethz.ch](http://www.didaktischeausbildung.ethz.ch)

### Educational Science

**General course offerings in the category Educational Science are listed under “Programme: Educational Science for Teaching Diploma and TC”:**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Markwalder</td>
</tr>
</tbody>
</table>

**Abstract**

Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar (ca. 16 h), 2) collaboration with elementary school teacher in a class (ca. 34 h, with approx. 50% spent in the elementary or middle school class and ca. 50% for preparation), and 3) final report (ca. 10 h). Registration implies participation in all 3 parts.

**Objective**

Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing Children, language problems etc.).

**Content**

Students learn more about the potential and challenges of pupils. They get to know the early stages of knowledge as well as the development of pre-concepts of students in their subject area. The seminar with a phase of cooperation consists of three phases: In the block seminar, pre-concepts are discussed in their own subject as well as theoretical inputs from developmental and cognitive psychology. During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students’ level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

**Prerequisites / notice**

https://www.minterlink.ch/student

### Human Learning (EW1)

**Number** 871-0240-00L

**Title** Human Learning (EW1)

**Abstract**

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

Thematic Schwerpunkte:

- Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen
- Lernformen:

**Lecture notes**

Folien werden zur Verfügung gestellt.

**Literature**


**Prerequisites / notice**

This lecture is only apt for students who want to enrol in the programs "Teaching Diploma" or "Teaching Certificate". It is about learning in childhood and adolescence.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>S. Maurer, P. Caprez, I. Sargenti</td>
</tr>
</tbody>
</table>

**Abstract**

The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite.

**Objective**

In this class, students will learn concepts and skills for coping with psychosocial demands of teaching.

(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).

**Data:** 02.07.2024 12:39

Autumn Semester 2024

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Abstract

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective

- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice

Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>871-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

Abstract

This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective

- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

Subject Didactics and Professional Training

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>272-0101-00L</td>
<td>Subject Didactics of Computer Science I</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>D. Komm, J. Hromkovic, G. Serafini</td>
</tr>
</tbody>
</table>

Abstract

The unit "Subject Didactics of Computer Science I" addresses key contributions of computer science to general education. The course deals with the thoughtful choice of educational contents for computer science classes, which takes into account its comprehensibility for different age groups as well as didactic approaches suitable for a successful knowledge transfer.

Objective

The general objective of the course consists in highlighting the tight connection between the mathematical and algorithmic way of thinking and the approaches adopted by engineering disciplines, and in reflecting on teaching approaches for sustainable computer science teaching activities.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

Content

The course "Subject Didactics of Computer Science I" addresses key contributions of computer science to general education. The chosen topics support the young learners in developing a unique and indispensable way of thinking, in enhancing their understanding of our world as well as in achieving university education entrance qualifications.

The main topics of the course unit "Subject Didactics of Computer Science I" are the didactics of finite state automata, of formal languages and of the introduction to programming. The unit focuses on contents of computer science that contribute to general education. This involves the understanding of fundamental scientific concepts such as algorithm, complexity, deterministic computation, automata, verification, testing and programming language as well as the way to embed them into a scientifically sound and didactically sustainable computer science course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Lecture notes

Unterlagen und Folien werden zur Verfügung gestellt.
Dokument: schriftliche Vorbereitung für Prüfungslektionen.

Wird von der Praktikumslehrperson bestimmt.

Communication

Adaptability and Flexibility

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Leerdiplom-Studierende müssen diese Lerneinheit zusammen mit dem Einführungspraktikum Informatik - 272-0201-00L - belegen.

271-0102-00L Teaching Internship Including Examination Lessons in Computer Science

Repetition of the Teaching Internship is excluded even if Examination Lessons are to be repeated.

Abstract

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons, and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content


Die Themen für die beiden Prüfungslektionen am Schluss des Praktikums erfahren die Studierenden in der Regel eine Woche vor dem Prüfungstermin. Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie bis am Vortrag um 12 Uhr den beiden Prüfungsexperten (Fachdidaktiker/-in, Departementsvertreter/-in) ein. Die gehaltenen Lektionen werden kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltenen Lektionen im Rahmen eines kurzen Kolloquiums.

Lecture notes

Dokument: schriftliche Vorbereitung für Prüfungslektionen.

272-0103-00L Mentored Work Subject Didactics Computer Science

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Lit. J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen" Lehrwerksreihe "Einfach Informatik"

https://einfachinformatik.inf.ethz.ch/


### Specialized Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>After this course, students will: Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features. Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs. Be able to learn new languages more rapidly. Be aware of many subtle problems of object-oriented programming and know how to avoid them.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages. The topics discussed in the course include among others: The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing); The key problems of single and multiple inheritance and how different languages address them; Generic type systems, in particular, Java generics, C# generics, and C++ templates; The situations in which object-oriented programming does not provide encapsulation, and how to avoid them; The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing; How to maintain the consistency of data structures.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Literature</strong></td>
<td>Will be announced in the lecture.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Prerequisites: Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience</td>
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</tr>
</tbody>
</table>

| 252-0535-00L | Advanced Machine Learning | W    | 10 credits | 3V+2U+4A   | C. Cotrini Jimenez |
| **Abstract** | Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects. |
| **Objective** | Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data. |
| **Content** | The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data. Topics covered in the lecture include: Fundamentals: What is data? Bayesian Learning Computational learning theory Supervised learning: Ensembles: Bagging and Boosting Max Margin methods Neural networks Unsupervised learning: Dimensionality reduction techniques Clustering Mixture Models Non-parametric density estimation Learning Dynamical Systems |
| **Lecture notes** | No lecture notes, but slides will be made available on the course webpage. |
Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### 263-2800-00L Design of Parallel and High-Performance Computing

**W** 9 credits 2V+2U+4A T. Hoefler

**Abstract**
Advanced topics in parallel and high-performance computing.

**Objective**
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

**Content**
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites / notice**
Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution.

### 272-0400-00L Mentored Work Specialised Courses in the Respective Subject with Educational Focus Computer Sc A

**W+** 2 credits 4A D. Komm, J. Hromkovic, G. Serafini

**Abstract**
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

**Objective**
The aim is for the students

- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

**Content**

**Literature**
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

**Prerequisites / notice**
The Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

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**Computer Science TC - Key for Type**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

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### Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0238-01L</td>
<td>Support and Diagnosis of Knowledge Acquisition Processes (EW3)</td>
<td>W</td>
<td>3</td>
<td>3S</td>
<td>C. M. Thurn, S. Daguati</td>
</tr>
</tbody>
</table>

**Prerequisites:** successful participation in 871-0240-00L "Human Learning (EW1)".

**Abstract**

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

**Objective**

The main goals are:

1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>assessed</td>
<td>fostered</td>
<td>fostered</td>
<td>fostered</td>
</tr>
</tbody>
</table>

**871-0242-06L**

**Cognitively Activating Instructions in MINT Subjects**

**Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).**

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

**Abstract**

This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

**Objective**

- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

**Prerequisites / notice**

Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

**871-0242-07L**

**Human Intelligence**

**Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).**

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

**Abstract**

The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

**Objective**

- Understanding research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

**see Educational Science Teaching Diploma**

### Subject Didactics in Computer Science

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>272-0101-00L</td>
<td>Subject Didactics of Computer Science I</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>D. Komm, J. Hromkovic, G. Serafini</td>
</tr>
</tbody>
</table>

**Abstract**

The unit "Subject Didactics of Computer Science I" addresses key contributions of computer science to general education. The course deals with the thoughtful choice of educational contents for computer science classes, which takes into account its comprehensibility for different age groups as well as didactic approaches suitable for a successful knowledge transfer.
Objective
The general objective of the course consists in highlighting the tight connection between the mathematical and algorithmic way of thinking and the approaches adopted by engineering disciplines, and in reflecting on teaching approaches for sustainable computer science teaching activities.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

Content
The course "Subject Didactics of Computer Science I" addresses key contributions of computer science to general education. The chosen topics support the young learners in developing a unique and indispensable way of thinking, in enhancing their understanding of our world as well as in achieving university education entrance qualifications.

The main topics of the course unit "Subject Didactics of Computer Science I" are the didactics of finite state automata, of formal languages and of the introduction to programming. The unit focuses on contents of computer science that contribute to general education. This involves the understanding of fundamental scientific concepts such as algorithm, complexity, determinism, computation, automata, verification, testing and programming language as well as the way to embed them into a scientifically sound and didactically sustainable computer science course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Lecture notes
Unterlagen und Folien werden zur Verfügung gestellt.

Literature
J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen"
Lehrwerksreihe "Einfach Informatik"
https://einfachinformatik.inf.ethz.ch/


Prerequisites / notice
Lehrdiplom-Studierende müssen diese Lerneinheit zusammen mit dem Einführungspraktikum Informatik - 272-0201-00L - belegen.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed
- Negotiation assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Abstract
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.
Thematische Schwerpunkte

2 credits

4A

Den Studierenden bietet das Einführungspraktikum einen Einblick in den Berufsalltag einer Lehrperson.

D. Komm

17P

D. Komm

Thematische Schwerpunkte

The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts

Teaching Internship in Computer Science

G. Serafini

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird

O

Lecturers

O

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird

6P

Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for

3 credits

272-0201-00L

Mentored Work Subject Didactics Computer Science

B

Mentored Work Subject Didactics in Computer Science for Teaching Diploma and for students upgrading TC to Teaching Diploma.

Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in

greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics

from a subject-based and pedagogical angle.

Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance

of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a

social angle too.

- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content

Themenatische Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


Literatur

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

272-0104-00L

Mentored Work Subject Didactics Computer Science

B

Mentored Work Subject Didactics in Computer Science for Teaching Diploma.

Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in

greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics

from a subject-based and pedagogical angle.

Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance

of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a

social angle too.

- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content

Themenatische Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


Literatur

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

► Professional Training

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Number

Title

Type

ECTS

Hours

Lecturers

272-0201-00L

Introductory Practical in Computer Science

Simultaneous enrolment in Subject Didactics of Computer Science I - course 272-0101-00L - is compulsory.

Abstract

During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and

Teaching Diploma

Teaching Diploma

Mentored Work Subject Didactics in Computer Science for Teaching Diploma and for students upgrading TC to Teaching Diploma.

Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance

of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a

social angle too.

- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content

Themenatische Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


Literatur

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

272-0202-00L

Professional Exercises

In the course Professional Exercises the students achieve additional school-relevant experiences. The students carry out individually

specified, practice related projects, in which they support, document or reflect on learning processes.

Objective

Achievement of additional school-relevant experiences. The students carry out individually specified, practice related projects, in which they support, document or reflect on learning processes.

Content

The course Professional Exercises offers the opportunity for additional school-relevant activities. The students are supported by the lecturers or by experienced teachers. They assist teachers at school, they create training systems and tests, correct the written homework of pupils and evaluate the progress of a class. The students create explanations and detailed solutions to exercises with respect to the actual knowledge of the pupils. A written assignment states the exact scope of the activity.

272-0203-00L

Teaching Internship in Computer Science

The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts

4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics

training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Autumn Semester 2024

Page 1402 of 2667
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter, G. Serafini

**Objective**
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

**Content**

**Literature**
Wird von der Praktikumslehrperson bestimmt.

**Prerequisites / notice**
Findet in der Regel am Schluss der Ausbildung, vor Ablegung der Prüfungslektionen statt.

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**272-0204-00L Teaching Internship in Computer Science II**

**W 4 credits 9P D. Komm, G. Serafini**

**Teaching Internship for students upgrading TC to Teaching Diploma.**

**Objective**
This is a supplement to the Teaching Internship required to obtain a Teaching Diploma in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.

**Content**
Die Studierenden können die Bedeutung von Unterrichtsthemen in ihrem Fach unter verschiedenen Blickwinkeln einschätzen. Sie kennen und beherrschen das unterrichtliche Handwerk. Sie können ein gegebenes Unterrichtsthema für eine Gruppe von Lernenden fachlich und didaktisch korrekt strukturieren und in eine adäquate Lernumgebung umsetzen. Es gelingt ihnen, die Balance zwischen Anleitung und Offenheit zu finden, sodass die Lernenden sowohl über den nötigen Freiraum wie über ausreichend Orientierung verfügen, um aktiv und effektiv flexibel nutzbares (Fach-)Wissen zu erwerben.

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**272-0205-01L Examination Lesson I in Computer Science**

**O 1 credit 2P D. Komm, G. Serafini**

**Simultaneous enrolment in "Examination Lesson II in Computer Science" (272-0205-02L) is compulsory.**

**Objective**
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

**Content**

**Lecture notes / Prerequisites / notice**
Nach Abschluss der übrigen Ausbildung.

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**272-0205-02L Examination Lesson II in Computer Science**

**O 1 credit 2P D. Komm, G. Serafini**

**Simultaneous enrolment in "Examination Lesson I in Computer Science" (272-0205-01L) is compulsory.**

**Objective**
On the basis of a specified topic, the candidate shows that they are in a position to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle.
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
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</table>

**Objective**
Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection

**Abstract**
After this course, students will:
- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.

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Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1403 of 2667
Content

The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing).
- The key problems of single and multiple inheritance and how different languages address them.
- Generic type systems, in particular, Java generics, C# generics, and C++ templates.
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them.
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing.
- How to maintain the consistency of data structures.

Literature

Will be announced in the lecture.

Prerequisites / notice

Prerequisites:
- Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience.

252-0535-00L Advanced Machine Learning

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
- Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-2800-00L Design of Parallel and High-Performance Computing

Abstract

Advanced topics in parallel and high-performance computing.

Objective

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

272-0400-00L Mentored Work Specialised Courses in the Respective Subject with Educational Focus Computer Sc A

Abstract

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

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Objective

The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content

Thematische Schwerpunkte:

Lernformen:

Literature

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

272-0401-00L Mentored Work Specialised Courses in the Respective O
Subject with Educational Focus Computer Sc B

Abstract

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective

The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content

Thematische Schwerpunkte:

Lernformen:

Literature

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

see Compulsory Elective Courses Teaching Diploma

Computer Science Teaching Diploma - Key for Type

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<thead>
<tr>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td></td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
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Key for Hours

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<tr>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Computer Science Master

► Majors

►► Major in Data Management Systems

►►► Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
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Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-3010-00L Big Data W 10 credits 3V+2U+4A G. Fourny

Abstract
The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?), (*), (+)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

263-3845-00L Data Management Systems W 8 credits 3V+1U+3A G. Alonso

Abstract The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Objective The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Literature The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.
### Elective Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-1414-00L</td>
<td>System Security</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>T. Capkun, S. Shinde</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems. In the second part, the focus is on system design and methodologies for building secure systems. Topics include common software faults (e.g., buffer overflows, etc.), bug detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control flow integrity), and language-supported security (e.g., memory safety). Along the lectures, model cases will be elaborated and evaluated in the exercises.</td>
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<td>Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore. We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Decision-making</td>
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<td>Personal Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
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<td>9</td>
<td>2V+2U+4A</td>
<td>T. Hofeller</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Advanced topics in parallel and high-performance computing.</td>
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<td><strong>Objective</strong></td>
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<td>Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore. We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.</td>
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<td>Become familiar with important technical concepts and with concurrency folklore. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although you will be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.</td>
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<td>263-3210-00L</td>
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<td>8</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.</td>
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<td><strong>Objective</strong></td>
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<td>In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be an rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.</td>
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<td>This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.</td>
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<td>The participation in the course is subject to the following condition:</td>
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<td>- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:</td>
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<td>Advanced Machine Learning</td>
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<td>Probabilistic Artificial Intelligence</td>
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### Major in Machine Intelligence

#### Core Courses

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<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td><strong>Abstract</strong></td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1408 of 2667
Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

Deep Learning

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://tas.inf.ethz.ch/teaching/pai-f18

Probabilistic Artificial Intelligence

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.
Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.
The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Competencies
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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Cooperation and Teamwork</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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Elective Courses

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<tr>
<td>252-3005-00L</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.</td>
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<tr>
<td>Objective</td>
<td>The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.</td>
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<tr>
<td>Content</td>
<td>This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.</td>
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<tr>
<td>Literature</td>
<td>Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.</td>
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<td>Reliable and Trustworthy Artificial Intelligence</td>
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<td>6</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
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<tr>
<td>Abstract</td>
<td>Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.</td>
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<td>Objective</td>
<td>Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.</td>
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<td>Content</td>
<td>The course is split into 4 parts:</td>
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<td>Privacy of Machine Learning</td>
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<tr>
<td>- Adversarial attacks and defenses on deep learning models,</td>
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<tr>
<td>- Automated certification of deep learning models (major trends: convex relaxations, branch-and-bound, randomized smoothing),</td>
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<tr>
<td>- Certified training of deep neural networks (combining symbolic and continuous methods).</td>
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<tr>
<td>Fairness of Machine Learning</td>
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<tr>
<td>- Threat models (e.g., stealing data, poisoning, membership inference, etc.),</td>
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<tr>
<td>- Attacking federated machine learning (across vision, natural language and tabular data),</td>
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<tr>
<td>- Differential privacy for defending machine learning,</td>
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<tr>
<td>- AI Regulations and checking model compliance.</td>
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<tr>
<td>Robustness, Privacy and Fairness of Foundation Models</td>
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<tr>
<td>- We discuss all previous topics, as well as programmability, in the context of latest foundation models (e.g., LLMs).</td>
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</tbody>
</table>

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
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<tr>
<td>assessed</td>
<td>assessed</td>
<td>Critical Thinking</td>
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<td>assessed</td>
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</tbody>
</table>

### Prerequisites / notice

263-5005-00L Artificial Intelligence in Education

**Abstract**

Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.

**Objective**

The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.

**Content**

The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as course curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

### Prerequisites / notice

There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

### Literature

Lecture notes

Lecture slides will be made available at the course Web site.

### Prerequisites / notice

263-5056-00L Applications of Deep Learning on Graphs

**Abstract**

Graphs are an incredibly versatile abstraction to represent arbitrary structures such as molecules, relational knowledge or social and traffic networks. This course provides a practical overview of deep (representation) learning on graphs and their applications.

**Objective**

Many established deep learning methods require dense input data with a well-defined structure (e.g. an image, a sequence of word embeddings). However, many practical applications deal with sparsely connected and complex data structures, such as molecules, knowledge graphs or social networks. Graph Neural Networks (GNNs) and general representation learning on graphs have recently experienced a surge in popularity because it addresses the challenge to effectively learn representations over said structures. In this course, we aim to understand the fundamental principles of deep (representation) learning on graphs, the similarities and differences to other concepts in deep learning, as well as the unique challenges from a practical point of view. Finally, we provide an overview of recent applications of graph neural networks.

**Content**

Introduction to GNN concepts: 1) problem-solving on graphs (node-, edge-, graph-level objectives), structural priors (inductive biases) of graph data, applications for graph learning. 2) Graph Neural Networks: convolutional, attentional, message passing; overview on the zoo of published operators. Relations to Transformers and DeepSets. 3) Expressivity of GNNs, 4) Scalability of Graph Neural Networks: Subsampling, Clustering (Pooling). 5) Augmentations and self-supervised learning on Graphs Application: Drug Discovery, Knowledge graphs, Temporal GNNs, Geometric GNNs, Deep Generative Models for Graphs.

### Prerequisites / notice

263-3210-00 Deep Learning or 263-0008-00 Computational Intelligence Lab; 252-0220-00 Introduction to Machine Learning; Statistics/Probability; Programming in Python; Unix Command Line.

263-5300-00L Guarantees for Machine Learning

**Abstract**

This course is aimed at advanced master and doctoral students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

**Content**

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Creative Thinking

Prerequisites / notice
- It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

Abstract
The course reviews solutions provided by machine learning to the most challenging questions in human genomics.

Objective
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content
- Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Techniques and Technologies
- Social Competencies: Communication

Prerequisites / notice
- It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

Main in Secure and Reliable Systems

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
</tbody>
</table>

Abstract
Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection

Objective
After this course, students will:
- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.

Content
The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
- The key problems of single and multiple inheritance and how different languages address them
- Generic type systems, in particular, Java generics, C# generics, and C++ templates
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing
- How to maintain the consistency of data structures

Literature
Will be announced in the lecture.

Prerequisites / notice
- Prerequisites:
  - Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience
Abstract
Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within
the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis,
and evaluation criteria for secure systems.

Objective
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering
addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality
software.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools
that can be applied within the different activities of the software development process, in order to improve the security of the resulting
systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security

252-1414-00L System Security

Abstract
The first part of the course covers general security concepts and hardware-based support for security.

In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

### Competencies

**Subject-specific Competencies**

- Assessing and applying Concepts and Theories
- Assessing and applying Techniques and Technologies
- Assessing and applying Analytical Competencies
- Assessing and applying Decision-making
- Assessing and applying Problem-solving
- Assessing and applying Communication
- Assessing and applying Adaptable and Flexible Thinking
- Assessing and applying Critical Thinking

**Method-specific Competencies**

- Assessing and applying Concepts and Theories
- Assessing and applying Techniques and Technologies
- Assessing and applying Analytical Competencies
- Assessing and applying Decision-making
- Assessing and applying Problem-solving
- Assessing and applying Communication
- Assessing and applying Adaptable and Flexible Thinking
- Assessing and applying Critical Thinking

**Social Competencies**

- Assessing and applying Social Competencies

**Personal Competencies**

- Assessing and applying Personal Competencies

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### 263-2800-00L Design of Parallel and High-Performance Computing

**W** 9 credits 2V+2U+4A  T. Hoefler

**Abstract**

Advanced topics in parallel and high-performance computing.

**Objective**

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become familiar with important technical concepts and with concurrency folklore.

**Content**

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites**

This course is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

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### 263-4640-00L Network Security

**W** 8 credits 2V+2U+3A  P. De Vaere, S. Frei, K. Paterson, A. Perrig

**Abstract**

Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

**Objective**

- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

**Content**

The course will cover topics spanning four broad themes with a focus on the first two themes:

1. Network defense mechanisms such as public-key infrastructures, TLS, and network intrusion-defense systems;
2. Network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. Analysis and inference topics such as traffic monitoring and network forensics; and

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

**Prerequisites**

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course. The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

**Competencies**

- Assessing and applying Concepts and Theories
- Assessing and applying Techniques and Technologies
- Assessing and applying Analytical Competencies
- Assessing and applying Decision-making
- Assessing and applying Media and Digital Technologies
- Assessing and applying Problem-solving
- Assessing and applying Project Management
- Assessing and applying Cooperation and Teamwork
- Assessing and applying Customer Orientation
- Assessing and applying Leadership and Responsibility
- Assessing and applying Self-presentation and Social Influence
- Assessing and applying Sensitivity to Diversity
- Assessing and applying Negotiation
- Assessing and applying Adaptable and Flexible Thinking
- Assessing and applying Creative Thinking
- Assessing and applying Critical Thinking
- Assessing and applying Integrity and Work Ethics
- Assessing and applying Self-awareness and Self-reflection
- Assessing and applying Self-direction and Self-management

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### 263-4658-00L Privacy Enhancing Technologies

**W** 7 credits 2V+1U+3A  F. Tramèr

**Abstract**

Privacy Enhancing Technologies

**Objective**

The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

**Competencies**

- Assessing and applying Concepts and Theories
- Assessing and applying Techniques and Technologies
- Assessing and applying Analytical Competencies
- Assessing and applying Decision-making
- Assessing and applying Problem-solving
- Assessing and applying Communication
- Assessing and applying Adaptable and Flexible Thinking
- Assessing and applying Critical Thinking
- Assessing and applying Self-awareness and Self-reflection
- Assessing and applying Self-direction and Self-management

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1415 of 2667
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Objective
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0579-00L</td>
<td>Hardware Security</td>
<td>W</td>
<td>8</td>
<td>2V+2U+2A</td>
<td>K. Razavi</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures and implementing some of these advanced attacks.</td>
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<tr>
<td>Objective</td>
<td>By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about: - security problems of commodity hardware that we use everyday and how you can defend against them. - relevant computer architecture and operating system aspects of these issues. - hands-on techniques for performing hardware attacks.</td>
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<tr>
<td>Literature</td>
<td>Slides, relevant literature and manuals will be made available during the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Experience with Linux, low-level systems programming and computer architecture.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>fostered</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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<tr>
<td>252-1411-00L</td>
<td>Security of Wireless Networks</td>
<td>W</td>
<td>6</td>
<td>2V+1U+2A</td>
<td>S. Capkun, K. Kostiainen</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course discusses physical layer aspects of wireless communication and a wide range of security-related topics in the domain of wireless technologies. It mainly targets computer science students. Though useful, a background in signal processing or physical layer concepts is not required. A basic understanding of security (e.g. as taught in 252-0211.00L Information Security) is recommended.</td>
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<tr>
<td>Objective</td>
<td>After this course, students should be able to describe and classify security goals of and attacks on various wireless networks and technologies, with an emphasis on physical layer aspects.</td>
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<tr>
<td>Content</td>
<td>- Introduction to wireless communication - Physical layer security schemes - Spreading techniques and their application in jamming-resilient communication and Global Navigation Satellite Systems (GNSSs) - Secure ranging with Ultra-Wide Band (UWB) - Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)</td>
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<td>Competencies</td>
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<td>Concepts and Theories</td>
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<tr>
<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>W</td>
<td>6</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
</tr>
<tr>
<td>Abstract</td>
<td>Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.</td>
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<tr>
<td>Objective</td>
<td>Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.</td>
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</table>
The course is split into 4 parts:

Robustness of Machine Learning

- Adversarial attacks and defenses on deep learning models.
- Certified training of deep neural networks (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across vision, natural language and tabular data).
- Differential privacy for defending machine learning.
- AI Regulations and checking model compliance.

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness (for both vision and tabular data).
- Enforcing group fairness (e.g., demographic parity, equalized odds).

Robustness, Privacy and Fairness of Foundation Models

- We discuss all previous topics, as well as programmability, in the context of latest foundation models (e.g., LLMs).


While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

The course covers topics in the theory of programming languages, types, and program verification, and how to construct and validate that theory with machine-checked proofs in the Coq proof assistant.

Students will learn how to develop machine-checked proofs, how to rigorously define the semantics of a programming language and its type system, and how to analyze and formally establish the guarantees of well-typed programs.

The course is split into 4 parts:

- The theory track (2V) will introduce operational semantics, type systems, and type soundness proofs, starting with the simply-typed lambda calculus and then continuing with increasingly expressive languages.
- The Coq track (2G) will begin with an introduction to machine-checked proofs and the Coq proof assistant. Afterwards we will mechanize the theory developed in the first track. This is the hands-on part of the course; students will carry out these proofs in Coq themselves with instructions from the lecturer.

The course will proceed in two parallel tracks:

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<td>Personal Competencies</td>
<td>Creative Thinking</td>
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</tbody>
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The course covers topics in the theory of programming languages, types, and program verification, and how to construct and validate that theory with machine-checked proofs in the Coq proof assistant.

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The course will proceed in two parallel tracks:

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Lecture notes

Will be made available on the course website.

Literature

Will be announced in the lecture.

Prerequisites / notice

A basic familiarity with propositional and first-order logic will be assumed. Courses with an emphasis on formal reasoning about programs (such as Formal Methods and Functional Programming) are advantageous background, but are not a requirement.

Competencies

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</table>

Abstract

Public-Key Encryption has had a significant impact by enabling remote parties to communicate securely via an insecure channel. Latest schemes go further by providing a fine-grained access control to the encrypted data.

Objective

The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.

Content

We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

Literature

Links to relevant research papers will be given in the course materials.

Prerequisites / notice

It is recommended for students to have prior exposure to cryptography, e.g., the D-INFK course "Digital Signatures" or "Applied Cryptography".

263-4657-00L Advanced Encryption Schemes

W 5 credits 2V+1U+1A to be announced

Abstract

Zero-Knowledge Proofs

Does not take place this semester.

Objective

The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.

Content

We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

Literature

Links to relevant research papers will be given in the course materials.

Prerequisites / notice

It is recommended for students to have prior exposure to cryptography, e.g., the D-INFK course "Digital Signatures" or "Applied Cryptography".

263-4665-00L Zero-Knowledge Proofs

W 5 credits 2V+1U+1A J. Bootle

Abstract

Zero-knowledge proofs are protocols which allow a prover to convince a verifier that a statement is true without leaking any information beyond that fact. This course is a detailed introduction to zero-knowledge proof protocols.
Objective
-To understand what it means for a zero-knowledge proof to be secure
-To construct and analyse various types of zero-knowledge proofs
-To understand some applications of zero-knowledge proofs

Content
The course will discuss interactive zero-knowledge proofs based on various cryptographic assumptions, and their applications in cryptography and the real world. The course may also describe some more advanced constructions of non-interactive proofs.

Lecture notes
The course notes will be written in English.

Prerequisites / notice
Students should have taken a first course in Cryptography (as taught in the Information Security course at Bachelor’s level). Experience with algebra (groups and finite fields) and probability is highly recommended.

Competencies

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Major in Theoretical Computer Science

Core Courses

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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
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</tbody>
</table>

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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<tr>
<th>Number</th>
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<tr>
<td>252-1425-00L</td>
<td>Geometry: Combinatorics and Algorithms</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>B. Gärtner, M. Hoffmann, P. Schnider, to be announced</td>
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</table>

Abstract
Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

Objective
The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains. In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

Content
Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in Rd, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan’s Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Lecture notes
Yes
263-4500-00L Advanced Algorithms W 9 credits J. Lengler, B. Häupler, M. Probst

Abstract This is a graduate-level course on algorithm design (and analysis). It covers a range of topics and techniques in approximation algorithms, sketching and streaming algorithms, and online algorithms.

Objective This course familiarizes the students with some of the main tools and techniques in modern subareas of algorithm design.

Content The lectures will cover modern topics in algorithm design and analysis, including the following: graph sparsifications while preserving cuts or distances, various approximation algorithms techniques and concepts, metric embeddings and probabilistic tree embeddings, online algorithms, multiplicative weight updates, streaming algorithms, sketching algorithms.

Lecture notes https://people.inf.ethz.ch/~aroeyskoe/AA23

263-4511-00L Information Theory I W 6 credits A. Lapidoth

Abstract This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

263-4517-00L Projects in Topological Data Analysis W 4 credits P. Schnider

Abstract This seminar complements the course „Introduction to Topological Data Analysis“. Students of the seminar will collaborate with students from international universities on concrete projects in topological data analysis, both theoretical and applied.

Objective Each student is expected to collaborate in an international working group with students from the partner universities. Each group works on one of the projects suggested by the lecturers, and is assigned a mentor. At the end of the semester, each working group presents their findings in a written report and an oral presentation.

Content This seminar complements the course Introduction to Topological Data Analysis. Students get to apply what they learned in the introductory course to concrete projects in the area of topological data analysis. These projects can be of theoretical nature, e.g., the design and analysis of a new algorithm, or applied, such as using methods from topological data analysis on concrete data sets.

Prerequisites / notice Successful participation in the course "Introduction to Topological Data Analysis" or equivalent background in topological data analysis is required.

Competencies Subject-specific Competencies Concepts and Theories fostered

Method-specific Competencies Analytical Competencies fostered

Decision-making fostered

Problem-solving fostered

Social Competencies Communication assessed

Cooperation and Teamwork assessed

263-4513-00L Structural Graph Theory W 5 credits R. M. Steiner

Abstract Structural graph theory forms, besides extremal graph theory, one of the two main pillars of modern graph theory. While the latter is concerned with maximizing the number of edges or the density of graphs, structural graph theory focuses on understanding the structural nature of all members of a class of graphs.

This course will cover several cornerstone results of structural graph theory.

Objective The students obtain a thorough understanding of the mathematical tools, techniques and results in structural graph theory, and understand the relations and applications which this rich theory has in other areas, such as computational complexity and logic. Additionally, they enhance their skillset for the design of efficient algorithms on structurally constrained classes of graphs.

Content Graph minors: Connectivity and versions of Menger's theorem, Planar graphs, Wagner's theorem, Tree-width, algorithmic applications of tree-width and Courcelle's theorem, balanced separators and Alon-Seymour-Thomas theorem, Grid Minor Theorem, Erdős–Pósa property and algorithmic applications, Graph Minor Structure Theorem, Membership complexity, Wagner's conjecture

Perfect graphs: Introduction to graph coloring and definition, Proof of the weak perfect graph theorem, Strong perfect graph theorem

Hadwiger's conjecture: 4-Color-Theorem and precise results, Extreme density of graphs excluding a fixed minor, Recent advances

Lecture notes Will be provided well before the start of the HS.

Literature Topics in Structural Graph Theory (Lowell W. Beineke, Robin J. Wilson) (Remark: Not a perfect fit for this course, but there is substantial overlap on some of the topics).

Prerequisites / notice The students should be familiar with the basics of the following areas: graph theory, linear programming, complexity theory and probabilistic methods. Having taken a previous course covering basic graph theory is strongly advised.
263-5300-00L Guaran1ees for Machine Learning

Does not take place this semester.

Abstract
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective
By the end of the semester students should be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks, and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression", "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

401-3054-14L Probabilistic Methods in Combinatorics

Abstract
This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content
The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

Literature
- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

Objective
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure $A$ one maps its elements to vectors in a linear space, and shows that the set $A$ is mapped to linearly independent vectors. It then follows that the cardinality of $A$ is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

### Contents

**Linear & Combinatorial Optimization**

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered
- Communication: assessed
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**Prerequisites / notice**

Students are expected to have a mathematical background and should be able to write rigorous proofs.

### 401-3901-00L Linear & Combinatorial Optimization

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<td>Prerequisites</td>
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**Abstract**

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

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**Content**

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Prerequisites / notice**

Students are expected to have a mathematical background and should be able to write rigorous proofs.

### 402-0448-01L Quantum Information Processing I: Concepts

**Abstract**

This theory part QIP I together with the experimental part 402-0448-02L QIP II (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in Physics.

**Objective**

By the end of the course students are able to explain the basic mathematical formalism of quantum mechanics and apply it to quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

**Content**

The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum circuits, quantum algorithms (Shor, Grover, Deutsch-Josza,..), stabilizer-based quantum error correction, fault-tolerant designs, the BB84 quantum key distribution protocol, and simple methods of quantum metrology.

**Lecture notes**

Will be provided.

**Literature**

- Quantum Computation and Quantum Information
- Michael Nielsen and Isaac Chuang
- Cambridge University Press

**Prerequisites / notice**

A good understanding of finite dimensional linear algebra is recommended.
Creative Thinking fostered

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★★★ Major in Visual and Interactive Computing

★★★ Core Courses

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<td>252-0543-01L</td>
<td>Computer Graphics</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>M. Gross, M. Papas</td>
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Abstract
This course covers fundamental and advanced concepts of modern computer graphics. Students will learn the fundamentals of digital scene representations, advanced physically-based light transport algorithms for generating photorealistic images from these scene representations, and inverse rendering methods for recovering digital scene representations from captured images.

Objective
At the end of the course, the students will be able to build a rendering system based on path-tracing algorithms. The students will learn the principles of physically-based rendering and computer graphics. In addition, the course is intended to stimulate the student's curiosity to explore the field of computer graphics in subsequent classes or on their own.

Content
We will begin with an introduction to light emission and radiometric quantities, followed by an exploration of geometry representations and texture mapping. Next, we will mathematically formulate the physics of light transport and appearance modeling. Subsequently, we will introduce relevant concepts from Monte Carlo integration and develop path-tracing algorithms to solve these equations by simulating light transport for direct and global illumination due to hard surfaces and participating media, such as fog, smoke, and translucent objects. Moreover, we will present techniques for significantly improving path-tracing efficiency, including importance sampling, multiple importance sampling, stratified sampling, denoising, and acceleration data structures. The course lectures will conclude with an overview of image-based capture and rendering methods. Topics covered will include geometry reconstruction, material acquisition, differentiable rendering, and image-based rendering.

Lecture notes
no

Literature
Books:
Physically Based Rendering: From Theory to Implementation
High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting

Multiple view geometry in Computer Vision

Prerequisites / notice
Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, and the Visual Computing course are recommended. The programming assignments will be in C++. This will not be taught in the class.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Project Management</td>
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</table>

Social Competencies
Communication fostered

Cooperation and Teamwork assessed

Leadership and Responsibility fostered

Personal Competencies
Creative Thinking assessed

Critical Thinking fostered

Integrity and Work Ethics fostered

Self-direction and Self-management fostered

★★★ Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0560-00L</td>
<td>Computer Vision and Artificial Intelligence for Autonomous Cars</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2P</td>
<td>C. Sakaridis</td>
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</table>

Abstract
This course introduces the core computer vision techniques and algorithms that autonomous cars use to perceive the semantics and geometry of their driving environment, localize themselves in it, and predict its dynamic evolution. Emphasis is placed on techniques tailored for real-world settings, such as multi-modal fusion, domain-adaptive and outlier-aware architectures, and multi-agent methods.
Mixed Reality

Objective
Students will learn about the fundamentals of autonomous cars and of the computer vision models and methods these cars use to analyze their environment and navigate themselves in it. Students will be presented with state-of-the-art representations and algorithms for semantic, geometric and temporal visual reasoning in automated driving and will gain hands-on experience in developing computer vision algorithms and architectures for solving such tasks.

After completing this course, students will be able to:
1. understand the operating principles of visual sensors in autonomous cars
2. differentiate between the core architectural paradigms and components of modern visual perception models and describe their logic and the role of their parameters
3. systematically categorize the main visual tasks related to automated driving and understand the primary representations and algorithms which are used for solving them
4. critically analyze and evaluate current research in the area of computer vision for autonomous cars
5. practically reproduce state-of-the-art computer vision methods in automated driving
6. independently develop new models for visual perception

Content
The content of the lectures consists in the following topics:

1. Fundamentals
   (a) Fundamentals of autonomous cars and their visual sensors
   (b) Fundamental computer vision architectures and algorithms for autonomous cars

2. Semantic perception
   (a) Semantic segmentation
   (b) Object detection
   (c) Instance segmentation and panoptic segmentation

3. Geometric perception and localization
   (a) Depth estimation
   (b) 3D reconstruction
   (c) Visual localization
   (d) Unimodal visual/lidar 3D object detection

4. Robust perception: multi-modal, multi-domain and multi-agent methods
   (a) Multi-modal 2D and 3D object detection
   (b) Visual grounding and verbo-visual fusion
   (c) Domain-adaptive and outlier-aware semantic perception
   (d) Vehicle-to-vehicle communication for perception

5. Temporal perception
   (a) Multiple object tracking
   (b) Motion prediction

The practical projects involve implementing complex computer vision architectures and algorithms and applying them to real-world, multi-modal driving datasets. In particular, students will develop models and algorithms for:
1. Semantic segmentation and depth estimation
2. Sensor calibration for multi-modal 3D driving datasets
3. 3D object detection using lidars

Prerequisites / notice
Students are expected to have a solid basic knowledge of linear algebra, multivariate calculus, and probability theory, and a basic background in computer vision and machine learning. All practical projects will require solid background in programming and will be based on Python and libraries of it such as PyTorch.

Competencies

<table>
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<th>Personal Competencies</th>
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<tr>
<td>assessed</td>
<td>Problem-solving</td>
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</table>

Lecture notes
Lecture slides are provided in PDF format.

Autumn Semester 2024

Data: 02.07.2024 12:39
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

**Seminar**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
227-2211-00L | Seminar in Computer Architecture | W | 2 credits | 2S | S. Sadrosadati, Y. Liang, O. Mutlu

**Abstract**
In this seminar course, we will cover fundamental and cutting-edge research papers in computer architecture. The course will consist of multiple components that are aimed at improving students' technical skills in computer architecture, critical thinking and analysis on computer architecture concepts, as well as technical presentation of concepts and papers in both spoken and written forms.

**Objective**
The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous presentation and discussion of selected papers during lectures and a written report delivered by each student at the end of the semester. This course is for those interested in computer architecture. Registered students are expected to attend every lecture, participate in the discussion, and create a synthesis report at the end of the course.

**Content**
Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

See https://safari.ethz.ch/architecture_seminar for past examples.

**Lecture notes**
All the materials will be posted on the course website: https://safari.ethz.ch/architecture_seminar/
Links to past course materials, including the synthesis report assignment, can be found in this page: https://safari.ethz.ch/architecture_seminar

**Literature**
Key papers and articles, on both fundamentals and cutting-edge topics in computer architecture will be provided and discussed. These will be posted on the course website.

See https://safari.ethz.ch/architecture_seminar for past examples.

**Prerequisites / notice**
Digital Design and Computer Architecture OR Digital Circuits / Computer Engineering

Students should (1) have done very well in Digital Design and Computer Architecture , Digital Circuits or a similar course and (2) show a genuine interest in Computer Architecture.

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**252-3811-00L** | Case Studies from Practice Seminar | W | 4 credits | 2S | M. Brandis

**Abstract**
Participants will learn how to analyze and solve IT problems in a systematic way, present findings to decision bodies, and defend their conclusions.

**Objective**
Participants understand the different viewpoints for IT-decisions in practice, including technical and business aspects, can effectively analyze IT questions from the different viewpoints and facilitate decision making.

**Content**
Participants learn how to systematically approach an IT problem in practice. They work in groups of three to solve a case from a participating company in depth, studying provided materials, searching for additional information, analyzing all in depth, interviewing members from the company or discussing findings with them to obtain further insights, and presenting and defending their conclusion to company representatives, the lecturer, and all other participants of the seminar. Participants also learn how to challenge presentations from other teams, and obtain an overview of learnings from the cases other teams worked on.

**Lecture notes**
Methodologies to analyze the cases and create final presentations. Short overview of each case.

**Prerequisites / notice**
Successful completion of Lecture "Information Technology in Practice".

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**252-4601-00L** | Current Topics in Information Security | W | 2 credits | 2S | S. Capkun, K. Paterson, S. Shinde

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, will officially fail the seminar.

**Competencies**

### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

### Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Negotiation

### Social Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1424 of 2667
### The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Objective**
The main goals of the seminar are the independent study of scientific literature and assessment of its contributions as well as learning and practicing presentation techniques.

**Content**
The seminar covers various topics in information security, including network security, cryptography and security protocols. The participants are expected to read a scientific paper and present it in a 35-40 min talk. At the beginning of the semester a short introduction to presentation techniques will be given.

**Selected Topics**
- security protocols: models, specification & verification
- trust management, access control and non-interference
- side-channel attacks
- identity-based cryptography
- host-based attack detection
- anomaly detection in backbone networks
- key-management for sensor networks

**Literature**
The reading list will be published on the course web site.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor(s)</th>
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<tr>
<td>252-5051-00L</td>
<td>Advanced Topics in Machine Learning</td>
<td>2</td>
<td>W</td>
<td>R. Cotterell, M. El-Assady, N. He, F. Yang</td>
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<tr>
<td>252-5701-00L</td>
<td>Seminar in Advanced Topics in Vision</td>
<td>2</td>
<td>W</td>
<td>M. Pollefeys, S. Tang</td>
</tr>
<tr>
<td>263-2100-00L</td>
<td>Research Topics in Software Engineering</td>
<td>2</td>
<td>W</td>
<td>R. Jung, M. Kokologiannakis, P. Müller</td>
</tr>
<tr>
<td>263-3504-00L</td>
<td>Hardware Acceleration for Data Processing</td>
<td>2</td>
<td>W</td>
<td>M. J. Giardino, M. Korenberg Friedman</td>
</tr>
</tbody>
</table>

- The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

- The seminar will cover various topics in information security: security protocols (models, specification & verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, key-management for sensor networks.

- The reading list will be published on the course web site.

- To accomplish that, students will study and present research papers in the area as well as participate in paper discussions. The papers will be presented in the first session of the seminar.

- The seminar covers advanced topics in computer vision, such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics. Each time the course is offered, a collection of research papers is selected and each student presents one paper to the class and leads a discussion about the paper and related topics.

- The goal is to get an in-depth understanding of actual problems and research topics in the field of computer vision as well as improve presentations and critical analysis skills.

- This seminar covers advanced topics in computer vision by reading and presenting classic and state-of-the-art papers. Each time the course is offered, a collection of research papers are selected covering topics such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction and others. Each student presents one paper to the class and leads a discussion about the paper and related topics.

- Students will be asked to study some papers from the recent software engineering literature and review them. This is an exercise in critical review and analysis. Active participation is required (a presentation of a paper as well as participation in discussions).

- This seminar will cover data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

- The papers will be presented in the first session of the seminar.

- Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

- The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

- If a student registers after that date, but does not attend the seminar, he/she will officially fail the seminar.

- The seminar offers a 2 credit course in the Autumn Semester 2024.
### 263-3713-00L Advanced Topics in Human-Centric Computer Vision

**Objective**
The goal of this seminar is not only to familiarize students with exciting new research topics, but also to teach basic scientific writing and oral presentation skills. The seminar will have a different structure from regular seminars to encourage more discussion and a deeper learning experience.

We will treat papers as case studies and discuss them in-depth in the seminar. Once per semester, every student will have to take one of the following roles:

- **Presenter:** Give a presentation about the paper that you read in depth.
- **Reviewer:** Perform a critical review of the paper.
- **All other students:** read the paper and submit questions they have about the paper before the presentation.

**Prerequisites / notice**
Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.

**Competencies**

- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

**Content**
This seminar aims to familiarize students with current research topics in fast graph algorithms and optimization.

### 263-4410-00L Seminar on Advanced Graph Algorithms and Optimization

**Objective**
Read papers on cutting edge research topics; learn how to give a scientific talk.

**Prerequisites / notice**
As prerequisite we require that you passed the course "Advanced Graph Algorithms and Optimization". In exceptional cases, students who passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

**Competencies**

- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

**Content**
This course introduces students to research topics around the principles and practices of designing user-centered programming interfaces. We will explore and discuss research topics on understanding programmers from specialized domains, interactive programming paradigms, collaborative interfaces, learning-oriented interfaces, and AI's impact on future programming interfaces.

### 263-4902-00L Seminar on User-Centered Programming Interfaces

**Objective**
The goal of this course is for students to gain a comprehensive understanding of state-of-the-art HCI research on user-centered programming interfaces. Additionally, students will develop skills in reading, presenting, summarizing, and critiquing research papers.

**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Adaptability and Flexibility

**Content**
This is a research seminar course where we meet weekly for two-hour discussions on selected papers. Students are expected to lead a presentation on the assigned topic and actively participate in the discussions.

### 263-5057-00L From Publication to the Doctor’s Office

**Objective**
The goal of this course is for students to gain a comprehensive understanding of state-of-the-art HCI research on user-centered programming interfaces.

**Competencies**

- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Adaptability and Flexibility

**Content**
This seminar aims to familiarize students with current research topics in fast graph algorithms and optimization.

### 263-3713-00L Advanced Topics in Human-Centric Computer Vision

**Objective**
The goal of this seminar is not only to familiarize students with exciting new research topics, but also to teach basic scientific writing and oral presentation skills. The seminar will have a different structure from regular seminars to encourage more discussion and a deeper learning experience.

We will treat papers as case studies and discuss them in-depth in the seminar. Once per semester, every student will have to take one of the following roles:

- **Presenter:** Give a presentation about the paper that you read in depth.
- **Reviewer:** Perform a critical review of the paper.
- **All other students:** read the paper and submit questions they have about the paper before the presentation.

**Prerequisites / notice**
Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.

**Competencies**

- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

**Content**
This seminar aims to familiarize students with current research topics in fast graph algorithms and optimization.

### 263-4410-00L Seminar on Advanced Graph Algorithms and Optimization

**Objective**
Read papers on cutting edge research topics; learn how to give a scientific talk.

**Prerequisites / notice**
As prerequisite we require that you passed the course "Advanced Graph Algorithms and Optimization". In exceptional cases, students who passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

**Competencies**

- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

**Content**
This course introduces students to research topics around the principles and practices of designing user-centered programming interfaces. We will explore and discuss research topics on understanding programmers from specialized domains, interactive programming paradigms, collaborative interfaces, learning-oriented interfaces, and AI's impact on future programming interfaces.

### 263-4902-00L Seminar on User-Centered Programming Interfaces

**Objective**
The goal of this course is for students to gain a comprehensive understanding of state-of-the-art HCI research on user-centered programming interfaces. Additionally, students will develop skills in reading, presenting, summarizing, and critiquing research papers.

**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Adaptability and Flexibility

**Content**
This is a research seminar course where we meet weekly for two-hour discussions on selected papers. Students are expected to lead a presentation on the assigned topic and actively participate in the discussions.

### 263-5057-00L From Publication to the Doctor’s Office

**Objective**
The goal of this course is for students to gain a comprehensive understanding of state-of-the-art HCI research on user-centered programming interfaces.

**Competencies**

- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Adaptability and Flexibility

**Content**
This seminar aims to familiarize students with current research topics in fast graph algorithms and optimization.
Abstract
This seminar course is designed to provide students with an opportunity to review and critically evaluate recent publications in medical field focusing on examples when CS method or bioinformatics/statistical technique has lead to an instrumentation, technique or drug approved for clinical practice use.

Objective
Throughout the course, students will read and analyze recent publications that demonstrate successful applications and sometimes failures in medicine. Promising research applications will also be discussed. The publications will cover a wide range of topics, including drug discovery, image analysis, prognosis models, and learning healthcare.

Content
The course will be structured as half lecture content and half seminar content. Lectures will review state of the medical practice prior to the discovery, obstacles in moving the field forward, and the need for improvement. Lecture will be followed by the seminar part where students will take turns presenting the assigned publications and leading the discussions. Students' presentations will focus on the main findings, and specific steps taken to translate the finding into clinical practice.

Publications will include examples of:
- specific CS/bioinformatics/statistics applications that has been brought to „bedside“ – has been approved by European Medicines Agency / Food and Drug Administration (USA) for clinical use or are widely used in medical research;
- examples of failures of how a discovery did not translate into an endproduct and why;
- current active research areas.

Covered topics will include some of the following:
- Drug discovery: Computer-aided drug discovery has become an integral part of the drug development process, enabling researchers to design and screen large libraries of molecules in silico (i.e., using computer simulations) before synthesizing and testing them in the lab. This has led to the discovery of new drug candidates for a wide range of diseases, including cancer, Alzheimer's disease, and HIV/AIDS.
- Genomics: Advances in computational genomics have enabled researchers to analyze and interpret large-scale genomic data, including DNA sequencing data, to identify disease-causing mutations, genetic risk factors, and drug targets. Examples of the development of personalized medicine, where treatments are tailored to an individual's genetic makeup. Examples when drug target identified by genetics has led to approved treatment.
- Imaging: Computer vision and image processing techniques have revolutionized medical imaging, enabling researchers to extract quantitative information from medical images that were previously inaccessible. This has led to the development of new diagnostic and prognostic tools for a wide range of diseases, including cancer, cardiovascular disease, and neurological disorders.
- Real-world data applications: emulation of clinical trials using electronic health records data.
- Large language models: Generating clinical trial protocols using large language models. Natural Language Processing for information extraction and interpretation.
- Learning healthcare systems: Advances in data analytics and information technology have enabled the development of learning healthcare systems, which use real-time data from electronic health records, medical devices, and other sources to improve patient outcomes and reduce healthcare costs. This has the potential to transform the way healthcare is delivered, making it more personalized, efficient, and effective.

In addition to the presentations, students will also be required to write critical reviews of the assigned publications throughout the course. The reviews will be evaluated based on the students’ ability to identify the strengths and weaknesses of the publications and to provide insightful and constructive feedback.

Prerequisites / notice
The course is intended for advanced undergraduate and graduate students with a background in computer science, bioinformatics, or a related field and interest in applying their skills to medical research.

This course assumes a working knowledge of R/Python and intermediate statistical analysis, including linear, logistic, survival regressions or ability and interest to learn them outside of the class.

Competencies

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<tr>
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263-5100-00L Topics in Medical Machine Learning
The deadline for deregistering expires at the end of the fourth week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar discusses recent relevant contributions to the fields of medical machine learning and related areas. Each participant will hold a presentation and lead the subsequent discussion.

Objective
Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize it for presentation to an audience. The necessary skills to successfully present the key points of existing research work are the same as those needed to communicate own research ideas. In addition to holding a presentation, each student will both contribute to as well as lead a discussion section on the topics presented in the class.

Content
The topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.

Prerequisites / notice
Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

263-5702-00L Seminar on Digital Humans
The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar covers advanced topic in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

Objective
The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills.
**Content**

This seminar covers advanced topics in digital humans including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All participants read the papers and participate in the discussion.

**Literature**

Individual research papers are selected each term. See https://vlg.inf.ethz.ch/, https://igl.ethz.ch/, and http://graphics.ethz.ch/ for example papers.

**Competencies**

<table>
<thead>
<tr>
<th>Type</th>
<th>Practical Work</th>
<th>Analytical Competencies</th>
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<tr>
<td>Lecturers</td>
<td>D. Basin</td>
<td>assessed</td>
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</table>

**Practical Work**

**Number** 252-0811-00L

**Title** Applied Security Laboratory

*Does not take place this semester.*

**Abstract**

Hands-on course on applied aspects of information security. Applied information security, operating system security, OS hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.

**Objective**

The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control, logging), application security with an emphasis on web applications (web server setup, common web exploits, authentication, session handling, code security), computer forensics, and risk analysis and risk management.

**Content**

This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and carry out experiments in order to better understand the need for secure implementation and configuration of IT systems and to assess the effectivity and impact of security measures. This part is based on a book and virtual machines that include example applications, questions, and answers.

The students will also complete an independent project: based on a set of functional requirements, they will design and implement a prototypical IT system. In addition, they will conduct a thorough security analysis and devise appropriate security measures for their systems. Finally, they will carry out a technical and conceptual review of another system. All project work will be performed in teams and must be properly documented.

**Lecture notes**


**Literature**

Recommended reading includes:

* Various: OWASP Guide to Building Secure Web Applications, available online
* O'Reilly, Loukides: Unix Power Tools, O'Reilly & Associates.
* Frisch: Essential System Administration, O'Reilly & Associates.
* NIST: Risk Management Guide for Information Technology Systems, available online as PDF
* BSI: IT-Grundschutzhandbuch, available online

**Prerequisites / notice**

* The lab allows flexible working since there are only few mandatory meetings during the semester.
* The lab covers a variety of different techniques. Thus, participating students should have a solid foundation in the following areas: information security, operating system administration (especially Unix/Linux), and networking. Students are also expected to have a basic understanding of HTML, PHP, JavaScript, and MySQL because several examples are implemented in these languages.
* Students must be prepared to spend more than three hours per week to complete the lab assignments and the project. This applies particularly to students who do not meet the recommended requirements given above. Successful participants of the course receive 8 credits as compensation for their effort.
* All participants must sign the lab's charter and usage policy during the introduction lecture.

**Number** 263-0650-00L

**Title** Practical Work

W 8 credits 17A

**Abstract**

Practical work shall foster the student's ability to solve technological scientific problems by applying acquired knowledge and social competencies.

**Objective**

see above

**Content**

Practical work refers either to a semester project or a lab course, which is conducted under the supervision of a professor of the department of computer science.

**Minors**

**Minor in Computer Graphics**

**Number** 252-0543-01L

**Title** Computer Graphics

W 8 credits 3V+2U+2A

**Abstract**

This course covers fundamental and advanced concepts of modern computer graphics. Students will learn the fundamentals of digital scene representations, advanced physically-based light transport algorithms for generating photorealistic images from these scene representations, and inverse rendering methods for recovering digital scene representations from captured images.

**Objective**

At the end of the course, the students will be able to build a rendering system based on path-tracing algorithms. The students will learn the principles of physically-based rendering and computer graphics. In addition, the course is intended to stimulate the student's curiosity to explore the field of computer graphics in subsequent courses or on their own.

**Content**

We will begin with an introduction to light emission and radiometric quantities, followed by an exploration of geometry representations and texture mapping. Next, we will mathematically formulate the physics of light transport and appearance modeling. Subsequently, we will introduce relevant concepts from Monte Carlo integration and develop path-tracing algorithms to solve these equations by simulating light transport for direct and global illumination due to hard surfaces and participating media, such as fog, smoke, and translucent objects. Moreover, we will present techniques for significantly improving path-tracing efficiency, including importance sampling, multiple importance sampling, stratified sampling, denoising, and acceleration data structures. The course lectures will conclude with an overview of image-based capture and rendering methods. Topics covered will include geometry reconstruction, material acquisition, differentiable rendering, and image-based rendering.

**Lecture notes** no
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Computer graphics, Computer Vision, and Human-Machine Interaction. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Prerequisites / notice

- Prerequisites: Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, and the Visual Computing course are recommended.
- The programming assignments will be in C++. This will not be taught in the class.

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
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<td>Concepts and Theories</td>
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<td>Communication</td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td>Project Management</td>
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<td>Self-direction and Self-management</td>
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<td>Fostered</td>
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</table>

252-0546-00L Physically-Based Simulation in Computer Graphics W 5 credits 2V+1U+1A S. Coros, B. Thomaszewski

Abstract

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Content

- The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Computer graphics, Computer Vision, and Human-Machine Interaction.
- The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Prerequisites / notice

- Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

263-5905-00L Mixed Reality W 5 credits 3G+1A Z. Bauer, C. Holz, M. Pollefeys

Abstract

The goal of this course is an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Objective

After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction.
2. Have a clear understanding on how to build mixed reality apps.
3. Have a good overview of state-of-the-art Mixed Reality.
4. Be able to critically analyze and assess current research in this area.

Content

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Computer graphics, Computer Vision, and Human-Machine Interaction. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Prerequisites / notice

- Prerequisites:
  - Good programming skills (C#/ C++/ Java etc.)
  - Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

#### Minor in Computer Vision

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0560-00L</td>
<td>Computer Vision and Artificial Intelligence for Autonomous Cars</td>
<td>W</td>
<td>6</td>
<td>3V+2P</td>
<td>C. Sakaridis</td>
</tr>
</tbody>
</table>

Abstract

This course introduces the core computer vision techniques and algorithms that autonomous cars use to perceive the semantics and geometry of their driving environment, localize themselves in it, and predict its dynamic evolution. Emphasis is placed on techniques tailored for real-world settings, such as multi-modal fusion, domain-adaptive and outlier-aware architectures, and multi-agent methods.

Objective

Students will learn about the fundamentals of autonomous cars and of the computer vision models and methods these cars use to analyze their environment and navigate themselves in it. Students will be presented with state-of-the-art representations and algorithms for semantic, geometric and temporal visual reasoning in automated driving and will gain hands-on experience in developing computer vision algorithms and architectures for solving such tasks.

After completing this course, students will be able to:
1. Understand the operating principles of visual sensors in autonomous cars.
2. Differentiate between the core architectural paradigms and components of modern visual perception models and describe their logic and the role of their parameters.
3. Systematically categorize the main visual tasks related to automated driving and understand the primary representations and algorithms which are used for solving them.
4. Critically analyze and evaluate current research in the area of computer vision for autonomous cars.
5. Practically reproduce state-of-the-art computer vision methods in automated driving.
6. Independently develop new models for visual perception.

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Content

The content of the lectures consists in the following topics:

1. Fundamentals
   (a) Fundamentals of autonomous cars and their visual sensors
   (b) Fundamental computer vision architectures and algorithms for autonomous cars

2. Semantic perception
   (a) Semantic segmentation
   (b) Object detection
   (c) Instance segmentation and panoptic segmentation

3. Geometric perception and localization
   (a) Depth estimation
   (b) 3D reconstruction
   (c) Visual localization
   (d) Unimodal visual/3D object detection

4. Robust perception: multi-modal, multi-domain and multi-agent methods
   (a) Multi-modal 2D and 3D object detection
   (b) Visual grounding and verbo-visual fusion
   (c) Domain-adaptive and outlier-aware semantic perception
   (d) Vehicle-to-vehicle communication for perception

5. Temporal perception
   (a) Multiple object tracking
   (b) Motion prediction

The practical projects involve implementing complex computer vision architectures and algorithms and applying them to real-world, multi-modal driving datasets. In particular, students will develop models and algorithms for:

1. Semantic segmentation and depth estimation
2. Sensor calibration for multi-modal 3D driving datasets
3. 3D object detection using lidars

Lecture notes

Lecture slides are provided in PDF format.

Prerequisites / notice

Students are expected to have a solid basic knowledge of linear algebra, multivariate calculus, and probability theory, and a basic background in computer vision and machine learning. All practical projects will require solid background in programming and will be based on Python and libraries of it such as PyTorch.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Social Competencies

- Communication
- Cooperation and Teamwork

Personal Competencies

- Creative Thinking
- Critical Thinking

263-3210-00L Deep Learning  W  8 credits  3V+2U+2A  T. Hofmann

Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is to provide a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/aml/

  Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/

  Introduction to Machine Learning
  https://las.inf.ethz.ch/teaching/introml-S19

  Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/stt/

  Computational Statistics
  https://stat.ethz.ch/lectures/ss19/comp-stats.php

  Probabilistic Artificial Intelligence
  https://las.inf.ethz.ch/teaching/pai-f18

263-5902-00L Computer Vision  W  8 credits  3V+1U+3A  M. Pollefeys, S. Tang, F. Yu

Abstract

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.
Objective
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

263-5905-00L Mixed Reality W 5 credits 3G+1A Z. Bauer, C. Holz, M. Pollefeys

Abstract
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

Objective
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

Content
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality / Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice
Prerequisites includes:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

Minor in Data Management

Number Title Type ECTS Hours Lecturers
252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensible to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content
Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-2800-00L Design of Parallel and High-Performance Computing W 9 credits 2V+2U+4A T. Hoefler

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space.

Become familiar with important technical concepts and with concurrency folklore.
Content

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of cache and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice

This course is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as database theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3010-00L

Big Data

W 10 credits 3V+2U+4A G. Fourny

Abstract

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and dont's. "Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

Content

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Literature

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces.

The course will cover the implementation aspects of data management systems using relational database engines as a starting point to foster understanding, training, and validation. The main objective is to provide insights into model design, training, and validation techniques.

The course will place an emphasis on understanding basic principles as they are key to understanding what problems may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

<table>
<thead>
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263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
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  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

263-3845-00L Data Management Systems W 8 credits 3V+1U+3A G. Alonso

Abstract
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Objective
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system-independent manner. The course will place an emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key-value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Literature
The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

227-0579-00L Hardware Security W 8 credits 2V+2U+2A K. Razavi

Abstract
This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is to familiarize the students with hardware security and to provide insights into model design, training, and validation.

Objective
By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:
- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Literature
Slides, relevant literature and manuals will be made available during the course.
### Prerequisites / notice
Experience with Linux, low-level systems programming and computer architecture.

### Competencies

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<th>Concepts and Theories</th>
<th>assessed</th>
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<td>Project Management</td>
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| Social Competencies           | Cooperation and Teamwork | fostered |
|                              |                          |          |
| Personal Competencies         | Adaptability and Flexibility | fostered |
|                              | Creative Thinking        | fostered |
|                              | Critical Thinking        | assessed |
|                              | Integrity and Work Ethics | fostered |
|                              | Self-direction and Self-management | fostered |

### 252-0463-00L Security Engineering

<table>
<thead>
<tr>
<th>W</th>
<th>7 credits</th>
<th>2V+2U+2A</th>
<th>D. Basin, S. Krstic</th>
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</table>

### Abstract
Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.

### Objective
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include:

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems.
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class

2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security

3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts

4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience

5. Model-driven security (Part II)
   - Continuation of above topics

6. Security patterns (design and implementation)

7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks

8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis

9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties

10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment

11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience

12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection

13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security
Content
- Introduction to wireless communication
- Physical layer security schemes
- Spreading techniques and their application in jamming-resilient communication and Global Navigation Satellite Systems (GNSSs)
- Secure ranging with Ultra-Wide Band (UWB)
- Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Social Competencies
Cooperation and Teamwork fostered
Personal Competencies
Critical Thinking fostered

252-1414-00L System Security W 7 credits 2V+2U+2A S. Capkun, S. Shinde
Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered
Social Competencies
Communication fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered

263-4640-00L Network Security W 8 credits 2V+2U+3A P. De Vaere, S. Frei, K. Paterson, A. Perrig
Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
(1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
(2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
(3) analysis and inference topics such as traffic monitoring and network forensics; and
(4) new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1436 of 2667
Advanced Encryption Schemes

Does not take place this semester.

Objective
The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.

Content
We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

Literature
Links to relevant research papers will be given in the course materials.

Prerequisites / notice
It is recommended for students to have prior exposure to cryptography, e.g. the D-INFK course "Digital Signatures" or "Applied Cryptography".

Zero-Knowledge Proofs

Objective
- To understand some applications of zero-knowledge proofs
- To construct and analyse various types of zero-knowledge proofs
- To understand some applications of zero-knowledge proofs beyond that fact. This course is a detailed introduction to zero-knowledge proof protocols.

Content
The course will discuss interactive zero-knowledge proofs based on various cryptographic assumptions, and their applications in cryptography and the real world. The course may also describe some more advanced constructions of non-interactive proofs.

Literature
Boneh & Shoup - A Graduate Course in Applied Cryptography

Prerequisites / notice
Basic knowledge in cryptography, probability and machine learning is recommended but not required.

Advanced Machine Learning

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.
Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.
Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.
PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
The course is split into 4 parts:

Robustness of Machine Learning

- Adversarial attacks and defenses on deep learning models.
- Certified training of deep neural networks (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across vision, natural language and tabular data).
- Differential privacy for defending machine learning.
- AI Regulations and checking model compliance.

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness (for both vision and tabular data).
- Enforcing group fairness (e.g., demographic parity, equalized odds).

Robustness, Privacy and Fairness of Foundation Models

- We discuss all previous topics, as well as programmability, in the context of latest foundation models (e.g., LLMs).


Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

Competencies

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263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann

Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/aml/

  Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/

  Introduction to Machine Learning
  https://las.inf.ethz.ch/teaching/introml-S19

  Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/slt/

  Computational Statistics
  https://stat.ethz.ch/lectures/ss19/comp-stats.php

  Probabilistic Artificial Intelligence
  https://las.inf.ethz.ch/teaching/pai-f18

263-5005-00L Artificial Intelligence in Education W 3 credits 1V+0.5U M. Sachan

Abstract

Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.

Objective

The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture notes
Lecture slides will be made available at the course Web site.

Literature
No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

Prerequisites / notice
There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

**263-5056-00L Applications of Deep Learning on Graphs**

<table>
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<th>W</th>
<th>4 credits</th>
<th>2G+1A</th>
<th>G. Rätsch</th>
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Abstract
Graphs are an incredibly versatile abstraction to represent arbitrary structures such as molecules, relational knowledge or social and traffic networks. This course provides a practical overview of deep (representation) learning on graphs and their applications.

Objective
Many established deep learning methods require dense input data with a well-defined structure (e.g. an image, a sequence of word embeddings). However, many practical applications deal with sparsely connected and complex data structures, such as molecules, knowledge graphs or social networks. Graph Neural Networks (GNNs) and general representation learning on graphs have recently experienced a surge in popularity because it addresses the challenge to effectively learn representations over said structures. In this course, we aim to understand the fundamental principles of deep (representation) learning on graphs, the similarities and differences to other concepts in deep learning, as well as the unique challenges from a practical point of view. Finally, we provide an overview of recent applications of graph neural networks.

Content
Introduction to GNN concepts: 1) problem-solving on graphs (node-, edge-, graph-level objectives), structural priors (inductive biases) of graph data, applications for graph learning. 2) Graph Neural Networks: convolutional, attentional, message passing; overview on the zoo of published operators. Relations to Transformers and DeepSets. 3) Expressivity of GNNs, 4) Scalability of Graph Neural Networks: Subsampling, Clustering (Pooling), 5) Augmentations and self-supervised learning on Graphs Application: Drug Discovery, Knowledge graphs, Temporal GNNs, Geometric GNNs, Deep Generative Models for Graphs.

Prerequisites / notice
- 263-3210-00 Deep Learning or 263-0008-00 Computational Intelligence Lab;
- 252-0220-00 Introduction to Machine Learning; Statistics/Probability; Programming in Python; Unix Command Line.

**263-5210-00L Probabilistic Artificial Intelligence**

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<th>W</th>
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<th>A. Krause</th>
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</table>

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
- Solid basic knowledge in statistics, algorithms and programming.
- The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Competencies

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**263-5300-00L Guarantees for Machine Learning**

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<th>7 credits</th>
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<th>F. Yang</th>
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Abstract
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective
By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.
Content
This course touching upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g., in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression", "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Competencies
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263-5351-00L Machine Learning for Genomics

W 6 credits 2V+2U+1A V. Boeva

Abstract
The course reviews solutions provided by machine learning to the most challenging questions in human genomics.

Objective
Over the last few years, the parallel development of machine learning methods and molecular profiling technologies for human cells, such as sequencing, created an extremely powerful tool to get insights into the cellular mechanisms in healthy and diseased contexts. In this course, we will discuss the state-of-the-art machine learning methodology solving or attempting to solve common problems in human genomics. At the end of the course, you will be familiar with (1) classical and advanced machine learning architectures used in genomics, (2) bioinformatics analysis of human genomic and transcriptomic data, and (3) data types used in this field.

Content
- Short introduction to major concepts of molecular biology: DNA, genes, genome, central dogma, transcription factors, epigenetic code, DNA methylation, signaling pathways
- Prediction of transcription factor binding sites, open chromatin, histone marks, promoters, nucleosome positioning (convolutional neural networks, position weight matrices)
- Prediction of variant effects and gene expression (hidden Markov models, topic models)
- Deconvolution of mixed signal (NMF, ICA)
- DNA, RNA and protein folding (RNN, LSTM, transformers)
- Data imputation for single-cell RNA-seq data, clustering and annotation (diffusion and methods on graphs)
- Batch correction (autoencoders, optimal transport)
- Survival analysis (Cox proportional hazard model, regularization penalties, multi-omics, multi-tasking)

Prerequisites / notice
Introduction to Machine Learning, Statistics/Probability, Programming in Python, Unix Command Line

Competencies
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Minor in Networking

Number Title Type ECTS Hours Lecturers
227-0575-00L Advanced Topics in Communication Networks W 6 credits 2V+2U L. Vanbever

Abstract
This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall. Repetition for credit is possible with the consent of the instructor.

Objective
The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments.

Content
In 2023, the course will cover advanced topics in communication networks such as:
- Advanced Internet routing (convergence, optimality, scalability, flexibility);
- Network programmability (OpenFlow, P4);
- Traffic engineering / Load Balancing;
- Network verification and synthesis;
- Network measurements;
- Network security;
- Upcoming transport protocols and technologies;
- Adaptive video streaming; and
- Network sustainability.

Lecture notes
Lecture notes and material will be made available before each course on the course website.

Literature
Relevant references will be made available through the course website.

Prerequisites / notice
Prerequisites: Communication Networks (227-0120-00L) or equivalents / programming skills (in any language) are expected (some of the exercises will involve coding).
252-1411-00L Security of Wireless Networks

W 6 credits 2V+1U+2A S. Capkun, K. Kostiainen

Abstract
This course discusses physical layer aspects of wireless communication and a wide range of security-related topics in the domain of wireless technologies. It mainly targets computer science students. Though useful, a background in signal processing or physical layer concepts is not required. A basic understanding of security (e.g. as taught in 252-0211-00L Information Security) is recommended.

Objective
After this course, students should be able to describe and classify security goals of and attacks on various wireless networks and technologies, with an emphasis on physical layer aspects.

Content
- Introduction to wireless communication
- Physical layer security schemes
- Spreading techniques and their application in jamming-resilient communication and Global Navigation Satellite Systems (GNSSs)
- Secure ranging with Ultra-Wide Band (UWB)
- Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
Social Competencies
- Communication
- Project Management
Personal Competencies
- Adaptability and Flexibility
- Cooperation and Teamwork

263-4640-00L Network Security

W 8 credits 2V+2U+2A P. De Vaere, S. Frei, K. Paterson, A. Perrig

Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
(1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
(2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
(3) analysis and inference topics such as traffic monitoring and network forensics; and
(4) new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course. The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

4> Minor in Programming Languages and Software Engineering

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1442 of 2667
Assessed

Formal Foundations of Programming Languages

6 credits

The course covers topics in the theory of programming languages, types, and program verification, and how to construct and validate that theory with machine-checked proofs in the Coq proof assistant.

Reliable and Trustworthy Artificial Intelligence

2V+1U+2P+1A

R. J. Jung

Assessed

Students will learn how to develop machine-checked proofs, how to rigorously define the semantics of a programming language and its type system, and how to analyze and formally establish the guarantees of well-typed programs.

2V+2U+1A

7 credits

Data: 02.07.2024 12:39

Autumn Semester 2024

Page 1443 of 2667
The course will proceed in two parallel tracks:

- The theory track (2V) will introduce operational semantics, type systems, and type soundness proofs, starting with the simply-typed lambda calculus and then continuing with increasingly expressive languages.

- The Coq track (2G) will begin with an introduction to machine-checked proofs and the Coq proof assistant. Afterwards we will mechanize the theory developed in the first track. This is the hands-on part of the course; students will carry out these proofs in Coq themselves with instructions from the lecturer.

**Prerequisites / notice**

A basic familiarity with propositional and first-order logic will be assumed. Courses with an emphasis on formal reasoning about programs (such as Formal Methods and Functional Programming) are advantageous background, but are not a requirement.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Problem-solving

- Personal Competencies
  - Critical Thinking

**263-2800-00L**

**Design of Parallel and High-Performance Computing**

<table>
<thead>
<tr>
<th>Content</th>
<th>The course will proceed in two parallel tracks:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture notes</td>
<td>Will be announced in the lecture.</td>
</tr>
<tr>
<td>Literature</td>
<td>Will be made available on the course website.</td>
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</table>

**303-1444-00L**

**System Security**

The lecture provides an introduction to modern security concepts, mechanisms, and their implementation in modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Along the lectures, model cases will be elaborated and evaluated in the exercises.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Problem-solving

- Personal Competencies
  - Critical Thinking

**263-2800-00L**

**Design of Parallel and High-Performance Computing**

<table>
<thead>
<tr>
<th>Content</th>
<th>Advanced topics in parallel and high-performance computing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space.</td>
</tr>
<tr>
<td>Objective</td>
<td>By the end of the course, students will be able to:</td>
</tr>
<tr>
<td>Content</td>
<td>The first half of the class will cover topics from cryptography such as secure multiparty computation, zero-knowledge proofs, PIR, ORAM, anonymous communication, etc. The second half will cover statistical notions of privacy, in particular differential privacy, and selected topics in machine learning privacy.</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>This course is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses “Parallele Programmierung (parallel programming)” and “Algorithmen und Datenstrukturen (algorithm and data structures)” or equivalent courses.</td>
</tr>
</tbody>
</table>

**Lecture notes**

Lecture notes will be posted on Moodle.

**Literature**

Boneh & Shoup - A Graduate Course in Applied Cryptography

References to relevant research papers will be provided.

**Minor in Systems Software**

### Minor in Systems Software

#### Number

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-1414-00L</td>
<td>System Security</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>S. Capkun, S. Shinde</td>
</tr>
<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>W</td>
<td>9</td>
<td>2V+2U+4A</td>
<td>T. Hoefler</td>
</tr>
</tbody>
</table>

### Competencies

- **Subject-specific Competencies**: Concepts and Theories, Techniques and Technologies
- **Method-specific Competencies**: Analytical Competencies, Problem-solving
- **Personal Competencies**: Critical Thinking

### Prerequisites

- Basic knowledge in cryptography, probability and machine learning is recommended but not required.

### Notice

- The Coq track (2G) will begin with an introduction to machine-checked proofs and the Coq proof assistant. Afterwards we will mechanize the theory developed in the first track. This is the hands-on part of the course; students will carry out these proofs in Coq themselves with instructions from the lecturer.
- A basic familiarity with propositional and first-order logic will be assumed. Courses with an emphasis on formal reasoning about programs (such as Formal Methods and Functional Programming) are advantageous background, but are not a requirement.

### Objective

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

### Content

- **Objective**: By the end of the course, students will be able to:
  - Reason about privacy concerns and the appropriate formalizations
  - Combine tools from cryptography and statistics to build privacy mechanisms
  - Assess, evaluate and prove privacy protection of a mechanism.

- **Content**: The first half of the class will cover topics from cryptography such as secure multiparty computation, zero-knowledge proofs, PIR, ORAM, anonymous communication, etc. The second half will cover statistical notions of privacy, in particular differential privacy, and selected topics in machine learning privacy.

### Lectures

Lecture notes will be posted on Moodle.

### Literature

Boneh & Shoup - A Graduate Course in Applied Cryptography

References to relevant research papers will be provided.
Advanced Machine Learning

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:

- What is data?
- Bayesian Learning

Computational leaning theory

Supervised learning:

- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:

- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-1425-00L Geometry: Combinatorics and Algorithms W 8 credits 3V+2U+2A B. Gärtner, M. Hoffmann, P. Schnider. To be announced

Abstract Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?).

Objective The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains. In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

Content Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in Rd, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Lecture notes Yes


Prequisites / notice Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

263-4500-00L Advanced Algorithms W 9 credits 3V+2U+3A J. Lengler, B. Häupler, M. Probst

Abstract This is a graduate-level course on algorithm design (and analysis). It covers a range of topics and techniques in approximation algorithms, sketching and streaming algorithms, and online algorithms.

Objective This course familiarizes the students with some of the main tools and techniques in modern subareas of algorithm design and analysis.

Content The lectures will cover modern topics in algorithm design and analysis, including the following: graph sparsifications while preserving cuts or distances, various approximation algorithms techniques, metric embeddings and probabilistic tree embeddings, online algorithms, multiplicative weight updates, streaming algorithms, sketching algorithms.

Lecture notes https://people.inf.ethz.ch/~aroeyskoe/AA23

Prequisites / notice This course is designed for masters and doctoral students and it especially targets those interested in theoretical computer science, but it should also be accessible to last-year bachelor students.

Sufficient comfort with both (A) Algorithm Design & Analysis and (B) Probability & Concentrations. E.g., having passed the course Algorithms, Probability, and Computing (APC) is recommended, though not required formally. If you are not sure whether you’re ready for this class or not, please consult the instructor.

Competencies Subject-specific Competencies Concepts and Theories
Method-specific Competencies Analytical Competencies Decision-making Problem-solving

263-4511-00L Projects in Topological Data Analysis W 4 credits 3G P. Schnider

Abstract This seminar complements the course "Introduction to Topological Data Analysis". Students of the seminar will collaborate with students from international universities on concrete projects in topological data analysis, both theoretical and applied.

Objective Each student is expected to collaborate in an international working group with students from the partner universities. Each group works on one of the projects suggested by the lecturers, and is assigned a mentor. At the end of the semester, each working group presents their findings in a written report and an oral presentation.

Content This seminar complements the course "Introduction to Topological Data Analysis". Students get to apply what they learned in the introductory course to concrete projects in the area of topological data analysis. These projects can be of theoretical nature, e.g., the design and analysis of a new algorithm, or applied, such as using methods from topological data analysis on concrete data sets.

Prerequisites / notice Successful participation in the course "Introduction to Topological Data Analysis" or equivalent background in topological data analysis is required.

Competencies Subject-specific Competencies Concepts and Theories
Method-specific Competencies Techniques and Technologies Analytical Competencies Media and Digital Technologies Problem-solving Project Management
Social Competencies Communication Cooperation and Teamwork

263-4513-00L Structural Graph Theory W 5 credits 2V+2A R. M. Steiner

Abstract Structural graph theory forms, besides extremal graph theory, one of the two main pillars of modern graph theory. While the latter is concerned with maximizing the number of edges or the density of graphs, structural graph theory focuses on understanding the structural nature of all members of a class of graphs. This course will cover several cornerstone results of structural graph theory.

Objective The students obtain a thorough understanding of the mathematical tools, techniques and results in structural graph theory, and understand the relations and applications which this rich theory has in other areas, such as computational complexity and logic. Additionally, they enhance their skillset for the design of efficient algorithms on structurally constrained classes of graphs.
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in individual exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically and converge (computationally))
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Content

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**Competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed

**Guarantees for Machine Learning**

*Does not take place this semester.*

**Objective**

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**Competencies**

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  - Concepts and Theories: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed

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Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)
### Subject-specific Competencies

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

### Literature


### Prerequisites / notice

Students are expected to have a mathematical background and should be able to write rigorous proofs.

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<th>Social Competencies</th>
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<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Sensitivity to Diversity</td>
<td>authored</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>Project Management</td>
<td>fostered</td>
</tr>
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### Abstract

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

### Objective

By the end of the course students are able to explain the basic mathematical formalism of quantum mechanics and apply it to quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum information-processing protocols. They are able to adapt and apply these concepts and methods to analyze and discuss quantum information-processing protocols.

### Prerequisites

Solid background in linear algebra.

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### Linear & Combinatorial Optimization

<table>
<thead>
<tr>
<th>401-3901-00L</th>
<th>W 10 credits</th>
<th>4V+2U</th>
<th>R. Zenklusen</th>
</tr>
</thead>
</table>

This theory part QIP I together with the experimental part 402-0448-02L QIP II (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in Physics.

### Abstract

The course covers the key concepts and formalism of quantum information processing. Topics include quantum algorithms, quantum error correction, quantum cryptography, and quantum metrology, with an emphasis on the power of quantum information processing beyond that of classical information processing. The formalism of quantum states, measurements, and channels is developed in detail.

### Objective

By the end of the course students are able to explain the basic mathematical formalism of quantum mechanics and apply it to quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

### Content

The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum circuits, quantum algorithms (Shor, Grover, Deutsch-Josza,...), stabilizer-based quantum error correction, fault-tolerant designs, the BB84 quantum key distribution protocol, and simple methods of quantum metrology.

### Literature

- Quantum Computation and Quantum Information
  - Michael Nielsen and Isaac Chuang
  - Cambridge University Press

---

### Quantum Information Processing I: Concepts

<table>
<thead>
<tr>
<th>402-0448-01L</th>
<th>W 5 credits</th>
<th>2V+1U</th>
<th>J. Renes</th>
</tr>
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</table>

This theory part QIP I together with the experimental part 402-0448-02L QIP II (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in Physics.

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### Literature

- Quantum Computation and Quantum Information
  - Michael Nielsen and Isaac Chuang
  - Cambridge University Press

---

### Prerequisites

A good understanding of finite dimensional linear algebra is recommended.
The course material will be made available by the lecturer.

### Adaptability and Flexibility

This InterFocus Course will provide a broad, hands-on introduction to Information Security, introducing adversarial thinking and security by design as key approaches to building secure systems.

#### Objective

The objective of this course is to learn how to solve algorithmic problems given by a textual description. This includes appropriate problem modeling, choice of suitable (combinatorial) algorithms, and implementing them (using C/C++, STL, CGAL, and BGL).

#### Literature

- J. Hromkovic, Teubner: Theoretische Informatik, Springer, 2004

#### Prerequisites / notice

Ideally, students will have taken the D-INFK Bachelors course "Information Security" or an equivalent course at Bachelors level.

#### Competencies

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Decision-making, Problem-solving, Adaptability and Flexibility, Creative Thinking, Critical Thinking

### Elective Courses

Students can individually choose from the entire Master course offerings in the area of Computer Science (or a closely related field), from ETH Zurich, EPF Lausanne, the University of Zurich and - but only with the consent of the Director of Studies - from all other Swiss universities.

#### Number

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0293-00L</td>
<td>Wireless Networking and Mobile Computing</td>
<td>W</td>
<td>4</td>
<td>2+1U</td>
<td>S. Mangold</td>
</tr>
</tbody>
</table>

#### Abstract

This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.

#### Objective

The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own add-on mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator. We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.

#### Content

- Wireless Communication, Wi-Fi, Contact Tracing, Bluetooth, Internet-of-Things, 5G, Standards, Regulation, Algorithms, Radio Spectrum, Cognitive Radio, Mesh Networks, Optical Communication, Visible Light Communication. We will address contact tracing, radio link budget, location distance measurements, and Bluetooth in more depth. MedTech basics are also provided.
- Chapters:
  1. Introduction
  2. Wireless Communication Basics
  3. IEEE 802.11 Wireless LAN (Wi-Fi)
  4. IEEE 802.15 Wireless PAN ( ZigBee & Bluetooth)
  5. Mobile Computing Algorithm Basics: Control and Game Theory
  6. Visible Light Communication
  7. Audio Communication
  9. Mobile Computing for Automated Medicine Delivery

#### Lecture notes

The course material will be made available by the lecturer.

- (1) The course webpage (look for Stefan Mangold's site)
- (2) The Java 802 protocol emulator “JEmula802” from https://bitbucket.org/field/jemula802
Prerequisites / notice
Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required).

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>fostered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>fostered</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Negotiation</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

263-0600-00L  
Research in Computer Science  
W 5 credits  11A  Professors

Abstract
Independent project work under the supervision of a Computer Science Professor.

Objective
Independent project work under the supervision of a Computer Science Professor.

Prerequisites / notice
Only students who fulfill one of the following requirements are allowed to begin a research project:
a) 1 lab (interfocus course) and 1 focus course
b) 2 core focus courses
c) 2 labs (interfocus courses)

A task description must be submitted to the Student Administration Office at the beginning of the work.

252-2111-00L  
Training for Programming Coaches  
W 1 credit  1S  M. Dahinden. L. E. Fässler

Abstract
The "Training for Programming Coaches" course is designed to prepare students for the role of a teaching assistant in an introductory programming course. The focus is on developing constructive coaching skills, particularly in giving effective feedback and competently conducting project presentations.

Objective
In this course, teaching assistants (TAs) will learn...

1. Understanding the role of teaching assistants:
   - recognising the responsibilities and expectations of teaching assistants.

2. Develop communication skills:
   - Using effective communication techniques.
   - Empathic listening and appropriate response to students' questions and concerns.

3. Giving feedback:
   - Understanding the principles of effective feedback.
   - Using methods to formulate feedback that is both developmental and motivating.
   - Avoiding common mistakes and misunderstandings when giving feedback.

4. Accepting project presentations:
   - Develop criteria for evaluating and assessing project presentations.
   - Apply objective assessment techniques to ensure fairness and consistency.
   - Methods to support and develop students' presentation skills.

5. Conflict resolution:
   - recognising and addressing potential conflict situations between students and teaching assistants.
   - Developing strategies for de-escalation and conflict resolution.

6. Didactic skills:
   - Teaching basic didactic principles to support the learning process of students.
   - Designing learning experiences and using tools that promote student understanding.
   - Workshops: Praktische Übungen, Simulationen und Rollenspiele zur Anwendung der erlernten Prinzipien in realitätsnahen Szenarien.
   - Peer-Feedback: Gegenseitiges Feedback unter den Kursteilnehmenden zur Förderung eines kollaborativen Lernumfelds.
   - Praktische Übungen: Anwendung der gelernten Konzepte im Übungsalltag mit Feedbacksequenzen durch die Kursleiter.
Competencies

Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Abstract
Venture Capital is important to fund big transformational ideas and is often misunderstood by tech or research entrepreneurs. This lecture immerses participants in the role of a Venture Capitalist (VC) to learn from experienced entrepreneurs and investors. In small teams, you work on a case of a real start-up and defend the case in a simulated investment committee consisting of experienced VCs.

Objective
After attending this course, students will be able to:
- Explain the differences between VC and founder thinking
- Evaluate if a start-up is suited for venture capital ("VC readiness")
- Evaluate founder friendliness of term sheets
- Determine funding needs & strategy for a start-up from research to first round
- Write and evaluate an investment memo

Content
The course is practically oriented and features guest speakers from leading venture capital firms and start-ups. The course embraces a unique perspective combining technology and investor thinking. The seminar is structured around five days with the following themes.

The detailed program is listed here: https://bit.ly/techinvesting23

Tying it all together. The last day is focused on simulating an investment committee meeting where the groups present their deal memos and discuss with the audience.

Competencies

Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management assessed

Abstract
In this seminar dedicated to digital innovations, we will bust the most stubborn myths around AI software patents such as "Software/AI isn't patentable", "AI patents are useless because you can't figure out if they are infringed", and many others. We will look at how AI and software start-ups can use patents to create a strong IP position in a scalable way.
After attending this course, students will be able to:
- Understand the basics of patenting in the digital space relevant for a global market
- Evaluate patenting opportunities with a more differentiated view on the topic
- Effectively use patents as a cost-effective part of a technology startup’s business plan
- Conduct patent searches, freedom-to-operate analysis and infringement analyses
- Write their first software/AI-related invention disclosure suitable for patenting

The course is focused on patenting digital innovations. It is designed for students with entrepreneurial interests that like to get a hands-on perspective on the topic of intellectual property strategies and patents.

The seminar includes presentations and practical group exercises to apply the acquired knowledge in practice. Entrepreneurs and leading IP experts are joining the seminar as guest speakers for discussion of real-life examples.

Topics that will be covered include:
- Best practices that any AI/software startups should know about IP and patents
- How investors evaluate a strong IP situation of a start-up
- How to efficiently monitor competitor patent activity and obtain “FTO”
- How to create an effective patent filing strategy that grows with the business
- How to efficiently create AI patents while not getting distracted from the founder’s core business

The course also contains a group work of a “FTO battle” where two teams compete in a freedom-to-operate analysis and individual work to write their first invention disclosure related to an AI or software topic.

<table>
<thead>
<tr>
<th>263-5058-00L</th>
<th>Technology and Entrepreneurship</th>
<th>W</th>
<th>3 credits</th>
<th>6S</th>
<th>A. Ilic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This course provides theoretical and practical insights into technology entrepreneurship. It focusses on the process of building new ventures from the idea to successfully scaling its business operations.</td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Students will develop internationally scalable and technology-based ventures using the Startup Navigator and ScaleUp Navigator Framework. They will learn how to structure and communicate these ideas to business angel and venture capital investors.</td>
<td></td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>This course provides theoretical and practical insights into technology entrepreneurship. It focusses on the process of building new ventures from the idea to successfully scaling its business operations. All tasks will lead students to give a complete pitch presentation in front of business experts and investors at the end of the seminar. The course structure will broadly follow the four dimensions of the St.Galler Startup NavigatorTM.</td>
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</tbody>
</table>

- Profiling (Problem-Solution-Fit): Here, students will learn to answer questions such as (1) what is your motivation to start a business? (2) What is the real customer problem? (2) What solution can be identified? (3) Who are the customers? (4) What is the job they need done? etc.
- Prototyping (Product-Market-Fit): After this section, students will be able to answer questions such as (1) What is the product or service that solves a customer need? (2) What is the value proposition? (3) What is the unique selling proposition? (4) What is the go-to-market strategy? (5) Who are the competitors? etc.
- Sourcing (Execution-Fit): Here, students will learn to address questions such as (1) What are important team roles? (2) How to leverage network and partners? (3) What are the requirements to execute the business? (4) Are there any IP-related challenges? (5) How may we co-create with others? etc.
- Scaling (Performance-Fit): In this section, students will reflect their concept in terms of scalability. They will learn to answer questions such as (1) How do we create purpose-driven culture for growth? (2) How do we scale up revenues? (3) How do we optimize our startup’s valuation in Series-X funding? (4) What kind of exit options are there? As a result, students develop internationally scalable and technology-driven businesses in teams. The special focus lies on the ability to successfully pitch these ventures to business angels or venture capital investors.

- Course slides and case-based literature provided by the instructor.
- Additional material pointed out by the instructor prior to and during the course.

<table>
<thead>
<tr>
<th>263-5907-00L</th>
<th>Geometry for Computational Design and Fabrication</th>
<th>W</th>
<th>1 credit</th>
<th>2G</th>
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</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The main intention of the course is to present geometric concepts that turned out to simplify the solution of problems in computational design and fabrication and hold promise to provide useful methodology for future research in this area.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Assuming some basic knowledge of elementary differential geometry of curves and surfaces in 3-dimensional Euclidean space, we will discuss concepts of classical constructive differential geometry and their discrete versions, with a focus on quadrilateral nets. Topics to be addressed include mappings between surfaces, conjugate parameterizations, principal parameterizations, developable surfaces and their applications in architectural structures, design of mechanical metamaterials and fabrication processes based on bending of material. Another focus is on geometric optimization problems, discussing mainly geometric ideas on initialization, regularization and the formulation of frequently appearing objective functions. A further topic is given by transformations which preserve important structures. This reaches into the sphere geometries of Möbius and Laguerre and transformations of nets. Finally, we present the basics of kinematical geometry, such as velocity fields and their use in registration algorithms, infinitesimal flexibility and the closely related static equilibrium of shells.</td>
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</table>

<table>
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<th>227-0811-00L</th>
<th>Creative Thinking Seminar</th>
<th>W</th>
<th>2 credits</th>
<th>2S</th>
<th>A. C. Notz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This seminar aims to understand better what creativity and creative thinking is by looking at the history of the creativity dispositive we are embedded in. We will look, learn and apply creative artistic practices to find innovative solutions. And we will also look beyond the artistic practices, into the creative potential of today’s technologies, especially Generative AI.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The students will gain insights into the concept and mechanics of Creative Thinking. They will trace the historical roots of creativity and its contemporary significance, explore how Creative Thinking intersects with modern innovations and technologies. The students will develop a comprehensive understanding of Creative Thinking and its practical application, start to cultivate the ability to generate innovative solutions through creative practices and will analyze the broader implications of creativity in various contexts.</td>
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<tr>
<td><strong>Content</strong></td>
<td>In the business world Creative Thinking is considered to be one of the “top ten skills” or “most In-Demand skill” in 2024. With Creative Thinking innovative solutions to problems are developed and not only a large number of ideas but also a variety and range of them are explored. The invention of the genius and look at different social subsystems like art, psychology, economy as well as field as fashion, advertisement and arts and crafts, how our understanding of creativity has emerged till today.</td>
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</table>

| 227-2210-00L | Computer Architecture | W | 8 credits | 6G+1A | S. Sadrosadati, O. Mutlu |

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1452 of 2667
Abstract

Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective

We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content

The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

Lecture notes

The video recordings of the lectures are expected to be made available after lectures.

Literature

We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

Prerequisites / notice


Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Social Competencies

- Communication
- Leadership and Responsibility

Personal Competencies

- Adaptability and Flexibility
- Critical Thinking
- Self-direction and Self-management

Science in Perspective

Note that no more than six credits can be accredited in this category.

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-INFK

Master's Thesis

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;

b. fulfilling any additional requirements necessary to gain admission to the master programme;

c. "Inter focus courses" (16 credits) completed;

d. "Focus courses" (26 credits) completed, from which at least 16 credits must come from the Major Core courses;

e. "Practical work" at least 8 credits completed.

f. In total, besides the master thesis, no more than 8 credits may be missing.

Abstract

The Master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective

To work independently and to produce a scientifically structured work under the supervision of a Computer Science Professor.

Content

Independent project work supervised by a Computer Science professor. The duration of the MT is 28 weeks (full-time), where the 28 weeks are composed of 26 weeks of actual processing time and 2 weeks to compensate for public holidays, sick days and other short-term absences.

Prerequisites / notice

Supervisor must be a professor at D-INFK or affiliated, see https://inf.ethz.ch/people/faculty.html

Computer Science Master - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Courses outside the curriculum</th>
<th>Suitable for doctorate</th>
<th>Compulsory</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
</tbody>
</table>

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1453 of 2667
<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS | European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Integrated Building Systems Master

### Main Courses

#### Fundamental Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1633-00L</td>
<td>Energy Conversion</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>I. Karlin, G. Sansavini, S. A. Hosseini</td>
</tr>
</tbody>
</table>

**Abstract**

This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.

**Objective**

Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course is to give a compact introduction into basics of Thermodynamics: Thermodynamic states and thermodynamic processes; Work and Heat; First and Second Laws of Thermodynamics. Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to building up students' intuition about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibrium. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included.

In the course "Energy Conversion", the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

**Content**

1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

**Lecture notes**

Lecture slides and supplementary documentation will be available online.

**Literature**


**Prerequisites / notice**

This course is intended for students outside of D-MAVT.

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: fostered
  - Problem-solving: assessed
  - Project Management: fostered
- Social Competencies
  - Communication: fostered
  - Cooperation and Teamwork: fostered
  - Customer Orientation: fostered
  - Leadership and Responsibility: assessed
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: fostered
  - Negotiation: fostered
- Personal Competencies
  - Adaptability and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: assessed

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<tr>
<th>401-0203-00L</th>
<th>Mathematics</th>
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<th>4</th>
<th>3V+1U</th>
<th>C. Busch</th>
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</table>

**Abstract**

This course gives an introduction to the following subjects: calculus, multivariable calculus, differential equations, linear algebra (systems of linear equations, matrices, eigenvectors).

**Objective**

Basic mathematical knowledge for engineers. Mathematics as a tool to solve engineering problems.

**Content**

This course gives an introduction to the following subjects: calculus, multivariable calculus, differential equations, linear algebra (systems of linear equations, matrices, eigenvectors).

**Literature**

- Tom M. Apostol, Calculus, Volume 1, One-Variable Calculus with an Introduction to Linear Algebra, 2nd Edition, Wiley
- Ulrich L. Rohde, Introduction to Differential Calculus : Systematic studies with engineering applications for beginners, Wiley.
- Ulrich L. Rohde, Introduction to Integral Calculus : Systematic studies with engineering applications for beginners, Wiley.
- A list will be handed out in the lecture.
The overall aim of the course is to raise students’ awareness and curiosity about the aspects that guide and shape our environment. Through lectures, readings, discussions, and exercises, the course seeks to achieve this goal by accumulating crucial notions from both theoretical and practice-based examples, and applying such knowledge into tasks of spatial planning.

At the end of this course, students should feel empowered to critically engage with the teaching topic from a variety of approaches. By taking up the lecture, the students should be able to analyse, interpret and reflect complex cross-scale tasks of spatial development and transformation, and to use their theoretical, methodical and professional knowledge to tackle them.

You as students will:

... assess present and future core challenges of spatial planning and development.
... discuss the role of spatial planning and development in shaping our living environment.
... differentiate the levels, scales and tasks of spatial planning instruments and processes.
... reflect on theoretical concepts and practical examples of decision-making of spatial tasks.
... identify and apply spatially relevant principles and systems for action-oriented planning and decision-making.
... acquire theoretical, methodological, practical know-how to examine, clarify, and solve tasks on spatial development.
Spatial development as a discipline deals with the development, (trans)formation, and arrangement of our urban environment. We simultaneously perceive and contribute to its transformation, making space the result of manifold intended and unintended changes. To mediate between different demands, interests and interventions of multiple actors, a forward-looking, evidence-based, and action-oriented planning is necessary. As guidance for future action, (spatial) planning has to be committed to the sustainable handling as well as just allocation of resources, in particular of the non-replicable resource land.

The course focuses on both theoretical concepts and practice-oriented approaches to gain knowledge and be equipped to address current issues in spatial planning and development. This is mirrored in the course’s structure made of both lectures and exercises.

The lecture series introduces necessary key concepts and covers the following main topics:
- Drivers of spatial development, inward development, core tasks and current challenges for (spatial) planners.
- Interplay of formal and informal planning instruments across scales and actors.
- Differentiation urban typologies, their characteristics and challenges
- Types of spatial analysis and key figures
- Planning approaches and the (political) steering of spatial development.
- Types of processes and participation in spatial development.
- Approaches for planning complex urban situations
- Concepts for sustainable development

Lecture notes
A course will be set up on Moodle for the provision of lectures and documents, to upload group deliverables and to ask questions in a discussion Forum. All documents provided are exclusively available for use within this course.

Competencies
Subject-specific Competencies
Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management fostered

Method-specific Competencies
Analytical Competencies assessed

Social Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management fostered

Core Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>101-0527-10L</td>
<td>Materials and Constructions</td>
<td>O</td>
<td>4 credits</td>
<td>2G</td>
<td>G. Habert, M. Posani</td>
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Abstract
Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Looking at material sourcing, properties and performance, as well as how they are integrated in the buildings (building envelope and detailing). Choice of material is done out of sustainability concern. Comfort, moisture transfer and building physics with hygroscopic materials.

Objective
Special focus on regenerative materials: earth, bio-based and reuse
The students will acquire knowledge in the following fields:
- Fundamentals of material performance
- Introduction to durability problems of building facades
- Materials for the building envelope:
  - Overview of structural materials and systems: concrete, steel, stone, earth, wood and bamboo
  - Insulating materials (bio-based vs conventional)
- Assessment of materials and components behaviour and performance
- Degradation risks connected to insulation and post-insulation
- Aspects of sustainability and durability

Content
- Special focus on comfort, moisture transfer and building physics with hygroscopic materials will be done.
- Introduction
- Sustainable cement and concrete
- Earth construction
- Stone
- Steel
- Bamboo
- Timber construction
- Building physic and conventional insulation
- Bio-based insulation and degradation risks with insulation
- Hygrothermal properties of building materials and dynamic numerical simulations
- Efficiency and sustainability of modern window glazing

Course will have general lectures
+ hands on lab @home experiments
+ group project for implementation of regenerative materials.

Competencies
Subject-specific Competencies
Techniques and Technologies assessed
Decision-making fostered
Problem-solving assessed
Communication assessed
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered
Negotiation fostered
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Self-awareness and Self-reflection fostered
151-8011-00L Building Physics: Theory and Applications

Abstract
Principles of heat and mass transport, hygro-thermal performance, durability of the building envelope and interaction with indoor and outdoor climates, applications.

Objective
The students will acquire in the following fields:
- Indoor and outdoor climate and driving forces.
- Hygrothermal properties of building materials.
- Building envelope solutions and their construction.
- Hygrothermal performance and durability.

Content
Principles of heat and mass transport, hygro-thermal performance, durability of the building envelope and interaction with indoor and outdoor climates, applications.

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Prerequisites / notice
Priority will be given to students in Integrated Building Systems Master (MIBS). Please send an email to the main lecturer, if you are not a MIBS student.

Competencies
Subject-specific Competencies
Concepts and Theories assessed

Technology and Innovation Management 363-0389-00L

Abstract
This course focuses on the sources of innovation (with a specific focus on digital technologies), the tools and techniques that organizations deploy to innovate routinely, and the strategic implications of technical change at different levels of analysis: individuals, firms and whole ecosystems.

Objective
This course intends to enable all students to:
- Acquire and understand the basic jargon, concepts and methods necessary to discuss, in a precise and concise manner, innovation processes and their outcomes at different levels of analysis
- Analyze the differences between individual and organizational decision processes and their innovative outcomes
- Evaluate critically the potential of different (digital) technologies to impact business organizations.

Content
Organizations and people are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small. How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

Lecture notes
Slides will be available on the Moodle page

Literature
Readings will be available on the Moodle page

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Social Competencies
Communication fostered
Leadership and Responsibility fostered
Sensitivity to Diversity fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered

Principles of Microeconomics 363-0503-00L

Abstract
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

Objective
The learning objectives of the course are:
(1) Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes: Lecture notes, exercises and reference material can be downloaded from Moodle.

Lecture notes


For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:


Complementary:


GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Prerequisites / notice

For MIBS Master students 151-8011-ooL Building Phyisc Theory & Application is a pre-requisit for this course or instructor permission.

For others no prior knowledge is required.

151-8007-00L

Urban Physics

Does not take place this semester.

W 3 credits 3G

D. W. Brunner, H. Wernli

Abstract

Urban physics: wind, wind comfort, pollutant dispersion, natural ventilation, driving rain, heat islands, climate change and weather conditions, urban acoustics and energy use in the urban context.

Objective

- Basic knowledge of the global microclimate and the local microclimate around buildings
- Impact of urban environment on wind, ventilation, rain, pollutants, acoustics and energy, and their relation to comfort, durability, air quality and energy demand
- Application of urban physics concepts in urban design
- Climate Change. The Global Picture: global energy balance, global climate models, the IPCC process. Towards regional climate scenarios: role of spatial resolution, overview of approaches, hydrostatic RCMs, cloud-resolving RCMs
- Urban micro climate and comfort: urban heat island effect, wind flow and radiation in the built environment, convective heat transport modelling, heat balance and ventilation of urban spaces - impact of morphology, outdoor wind comfort, outdoor thermal comfort, urban energy and urban design. Energy performance of building quarters and cities, decentralized urban energy production and storage technologies, district heating networks, optimization of energy consumption at district level, effect of the micro climate, urban heat islands, and climate change on the energy performance of buildings and building blocks.
- Wind driving rain (WDR): WDR phenomena, WDR experimental and modeling, wind blocking effect, applications and moisture durability scenarios: role of spatial resolution, overview of approaches, hydrostatic RCMs, cloud-resolving RCMs
- Urban acoustics, noise propagation through the urban environment, meteorological effects, urban acoustic modeling, noise reduction measures, urban vegetation
- Practical exercise on climatic data collection and analyze

Lecture notes

The course lectures and material are provided online via Moodle.

Lecture notes

Prerequisites / notice

066-0421-00L

Building Systems I

O 3 credits 3G

I. Hischier, L. Baldini, L. O. Grobe, A. Schlüter, M. Sulzer

Abstract

Building Systems I gives an overview of fundamentals and concepts relevant for the design of building systems.

The course has the following learning objectives:

- Knowledge of the fundamentals, principles and technologies for building heating, cooling, ventilation and electricity supply.
- Knowledge of the integration and interdependencies of building systems and building structure, construction and aesthetics
- Ability to estimate relevant quantities and qualities for heating/cooling/ventilation/electricity of buildings and the related supply systems
- Ability to evaluate and choose an approach for sustainable heating/cooling/ventilation/electricity, the system and its components
- Synthesis in own integrated design projects
1. Comfort & Environment

Currently, Life Cycle Assessment (LCA) is applied as an ex-post design evaluation of buildings, but rarely used to improve the building during the design process. The aim of this course is to apply LCA during the design of buildings by means of a digital, parametric tool. The necessary fundamentals of the LCA method will be taught following a lecture on demands approach.

Objective

The course will follow two main objectives and a third optional objective, depending on the design projects the students choose. At the end of the course, the students will:

1. Know the methodology of LCA
2. Be able to apply LCA in the design process to assess and improve the environmental performance of their projects
3. Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation

Content

The course will be structured into two parts, each making up about half of the semester.

Part I: Exercises with lectures on demand

The first six individual courses will follow the "lectures on demand" approach. Small "hands-on" exercises focusing on one specific aspect will be given out and the necessary background knowledge will be provided in the form of short input lectures when questions arise. The following topics will be discussed during the first part:

1) LCA basic introduction
2) System boundaries, functional unit, end of life
3) Carbon budget and LCA benchmarks
4) BIM-LCA, available calculation tools and databases
5) Integrated analysis of environmental and cost assessment
6) Bio-based carbon storage

Part II: Project-based learning

In the second part, the students will work on their individual project in groups of three. For the design task, the students will bring their own project and work on improving it. The projects can be chosen depending on the students background and range from buildings to infrastructure projects. Intermediate presentations will ensure the continuous work and make sure all groups are on the same level and learn from each other. During this part, the following hands-on tutorials will be given:

1) Introduction to Rhinoceros 6 and 7
2) Introduction to grasshopper
3) Integrated assessment tools (ladybug tools)
4) Introduction to in-house grasshopper plugin for LCA analysis

Lecture notes

As the course follows a lecture on demand approach, the lecture slides will be provided after each course.

Literature

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

Prerequisites / notice

The students are expected to work out of class as well. The course time will be used by the teachers to answer project-specific questions. The lecture series will be conducted in English and is aimed at students of master's programs, particularly in civil engineering and MIBS. No lecture will be given during Seminar week.

Competencies

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<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Techniques and Technologies</td>
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<td>Adaptability and Flexibility</td>
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151-0209-00L Renewable Energy Technologies W 4 credits 3G A. Bardow, E. Casati

Abstract

The first part of the course covers the engineering aspects of the prominent renewable energy technologies: solar (PV and thermal), wind, hydro, geothermal and bioenergy. We further discuss energy storage, renewable transport and renewable heating & cooling. Finally, we introduce the key concepts of the economics of renewable energy and its integration in the energy system.

Objective

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Lecture notes

Lecture Notes containing copies of the presented slides.

Prerequisites / notice

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

Competencies

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101-0123-00L Structural Design W 3 credits 2G J. Pauli, F. Bertagna

Abstract

The goal of the course is to introduce students to Structural Design. The course fosters the development of a design thinking that emerges from the coexistence of a number of design parameters and performance criteria related to force flow, construction technologies, material use, and spatial qualities.
After a successful completion of the course, students will be able to:
1. Critically evaluate structural design concepts based on their impact and implications beyond the sole structural performance
2. Identify the most relevant design parameters and performance criteria for a given design task and select adequate tools to effectively integrate them as part of the design process
3. To develop structural systems in compliance with structural, spatial, and environmental design aspects simultaneously


The course is aimed at first-year bachelor students in the Department of Mechanical and Process Engineering. It is an introductory course on Energy Systems Analysis, providing an overview of the field and its application.

The aim of the course is to introduce students to Structural Design. The course fosters the development of a design thinking that emerges from the coexistence of a number of design parameters and performance criteria related to force flow, construction technologies, material use, and spatial qualities. Students will learn about diverse tools that allow for controlling such a complex blend of parameters and criteria at the interface between different disciplines such as structural engineering and architecture. These tools will include physical models, graphical methods, and digital tools. After a series of lectures and workshops, students will work on a design exercise that represents the core of the entire course. The design exercise is an opportunity to deal with an open-ended task that does not admit a univocal answer. In fact, besides structural performance, design options will be discussed and evaluated through a set of criteria including spatial qualities, constructability, and environmental footprint.

**Subject-specific Competencies**
- Concepts and Theories fostered
- Techniques and Technologies fostered
- Analytical Competencies fostered
- Decision-making fostered
- Problem-solving fostered
- Communication fostered
- Critical Thinking fostered
- Self-awareness and Self-reflection fostered

**Method-specific Competencies**
- Cooperation and Teamwork fostered
- Problem-solving fostered

**Social Competencies**
- Negotiation fostered
- Sensitivity to Diversity fostered
- Cooperation and Teamwork fostered

**Personal Competencies**
- Adaptable and Flexible fostered
- Creativity fostered
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered

**Objective**
- Analyse energy technologies with respect to different criteria/characteristics
- Discuss and debate the pros and cons of different ESA models/approaches (for specific applications)
- Explain the system-level interdependencies/interconnections within the energy system
- Evaluate the effect of uncertainties and "the human dimension" on ESA and scenarios

The course provides an introduction and overview to the most well-established models and methods of energy systems analysis, in each case introducing students to the theory and assumptions of the method, strengths and weaknesses of the specific approach, and case studies for exemplary energy technologies and systems. The students are taught to understand and will be able to apply the basic principles of these methods in the context of targeted assignments relating to real-world energy systems.

No specific prerequisites, some background in energy-related topics in the Bachelor would be beneficial.
Content
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Literature
Information about relevant literature will be given in the lecture.

Prerequisites / notice
This course is meant for students who did not already attend the course “Mathematical Optimization”, which is a more advance lecture covering similar topics. Compared to “Mathematical Optimization”, this course has a stronger focus on modeling and applications.

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<td>world objectives to tackle climate change.</td>
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Autumn Semester 2024
**Transport Planning Methods**

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**Abstract**
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

**Objective**
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

**Content**
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

**Literature**

**Lecture notes**
Moodle platform (enrollment needed)

**Prerequisites / notice**
- TEACHING FORMAT / ATTENDANCE: The course includes several mandatory sessions that participants must attend to successfully earn credit points. It is not possible to take the class purely online.
- For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

**Subject-specific Competencies**
- Concepts and Theories
  - assessed
- Analytical Competencies
  - assessed
- Decision-making
  - fostered
- Problem-solving
  - assessed

**Method-specific Competencies**
- Communication
  - fostered
- Cooperation and Teamwork
  - fostered
- Negotiation
  - fostered

**Social Competencies**
- Creative Thinking
  - fostered
- Critical Thinking
  - assessed
- Self-awareness and Self-reflection
  - fostered

**Personal Competencies**

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**Introduction to Computational Physics**

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**Abstract**
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

**Objective**
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

**Content**
Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.
Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro-codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

Future climate change can only kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.
Objective

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature


363-0565-00L Principles of Macroeconomics

Abstract

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

Content

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Lecture notes

The course Moodle page contains announcements, course information and lecture slides.

Literature


This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Competencies

Subject-specific Competencies

Methods-specific Competencies

Social Competencies

Personal Competencies

Informatics

Abstract

Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists, tables and relational databases, introduction to programming.

252-0839-00L

W 2 credits 2G

M. Dahinden, L. E. Fässler

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1465 of 2667
Objective

The students learn to...
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data,
- query databases and understand and evaluate the corresponding database model,
- encode a problem into a program, test the program, and correct errors,
- implement models from the natural sciences as a simulation.

Content

1. Modeling and simulations
2. Data management with lists and tables
3. Data management with a relational database
4. Introduction to programming with Python 1 (variables & data types)
5. Introduction to programming with Python 2 (control structures & logic)
6. Introduction to programming with Python 3 (sequential data structures)

Lecture notes
All materials for the lecture are available at www.evim.ethz.ch

Literature

Prerequisites / notice
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

Competencies

Subject-specific Competencies
Concepts and Theories
fostered
Techniques and Technologies
assessed

Method-specific Competencies
Analytical Competencies
assessed
Decision-making
fostered
Media and Digital Technologies
assessed
Problem-solving
assessed
Project Management
fostered

Social Competencies
Communication
assessed
Cooperation and Teamwork
fostered

Personal Competencies
Adaptability and Flexibility
fostered
Creative Thinking
assessed
Critical Thinking
assessed
Self-awareness and Self-reflection
fostered
Self-direction and Self-management
fostered

101-0007-00L Project Management for Construction Projects W 4 credits 3S B. Hofer

Abstract
This course is designed to lay down the foundation of the different concepts, techniques, and tools for successful project management of construction projects.

Objective
The goal is that at the end of this course students should have a good understanding of the different project management knowledge areas, the phases required for successful project management, and the role of a project manager. To demonstrate this, students will work in groups in different case studies to apply the concepts, tools and techniques presented in the class.

Two 3 to 4 hours sessions towards the end of the lecture series will introduce a practical project to allow the teams to demonstrate the tools and techniques learned during the semester.

The course will have a final quiz that will be graded.

The course will be supported by several external lecturers from the construction industry and demonstrations of real-life case studies.

Content
The main content of the course is summarized in the following topics:
- Introduction, project and organization structures
- Project scheduling
- Resource management
- Risk management
- Project estimating and budgeting
- Project financing and Public-Private Partnerships (PPP)
- Construction Process management and controlling
- Sustainability management
- Reporting and Communication
- Interpersonal skills and leadership in Construction projects
- Advanced Topics in Construction Project management (BIM / 5D planning, Ki)
- Project Evaluation and Closure

Lecture notes
The slides for the class will be available for download from Moodle at least one day before each class. Copies of all necessary documents will be distributed at appropriate times.

Literature
Relevant readings will be recommended throughout the course (and made available to the students via Moodle).

Prerequisites / notice
The students will be randomly assigned to teams. Students will be graded as a team based on the final Project proposal with the in-class oral presentation as well as a final exam (50% exam and 50% project). Homework will not be graded but your final report and presentation will consist mostly of your homework assignments consolidated and put in a report and presentation format.
Competencies

Subject-specific Competencies

Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies

Analytical Competencies fostered
Decision-making assessed
Problem-solving assessed
Project Management assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation assessed

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

376-1177-00L Human Factors I

Abstract
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.

Objective
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBiS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

103-0569-00L European Aspects of Spatial Development

Abstract
Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Objective
Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways to their engagement in European spatial policy-making

Content
- European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system; EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the notion of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

Lecture notes
The documents for the lecture will be provided at the moodle.
The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students. Particularly suitable for students of D-ARCH.

Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.

2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).

3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.

4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality

5. Explain what bad design is and why it matters.

6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".

7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.

8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.

9. Explain what data independence is all about and didn't age a bit since the 1970s.

10. Explain, in the big picture, how a relational database is physically implemented.

11. Know and deal with the natural syntax for relational data, CSV.

12. Explain the data cube model including slicing and dicing.

13. Store data cubes in a relational database.

14. Map cube queries to SQL.

15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).

- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:

- available on Moodle
- assessed

B. Bickel

fostered

How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-
This course aims to provide a graduate-level introduction to machine learning, with a particular focus on scientific machine learning for applications in the design and construction phases of projects from architecture and civil engineering.

Upon completion of the course, the students will be able to:
1. Understand main ML background theory and methods.
2. Assess a problem and apply ML and DL in a computational framework accordingly.
3. Incorporate scientific domain knowledge in the SciML process.
4. Define, plan, conduct and present a SciML project.

The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
2. Incorporation of Domain Knowledge into ML and DL.
4. ML training, validation and testing pipelines for academic and research projects.

A comprehensive series of computer/laboratory exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Suggested Reading:
- S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016
- A. E. Braunschweig - Sustainability problems of the current economic system and its measuring units; 2 credits

Familiarity with Python is advised.

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic will profit more from this course after reading an appropriate textbook before or at the beginning of this course, e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2).

This course is meant for any interested student.

Students will get small homework exercises to apply the course topics and methods issues.

- an intro into sustainability issues of supply chain management
- stakeholder management and sustainability oriented communication
- single score environmental assessment methods, with a focus on the 'ecopoints' method

Companies
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), incl. practical examples of companies.
- Life Cycle Costing, as part of Life Cycle Management
- The concept of ‘Continuous Improvement’, and its application to environmental management
- Life Cycle Costing, as part of Life Cycle Management
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), incl. practical examples of companies.

- single score environmental assessment methods, with a focus on the 'ecopoints' method
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small homework exercises to apply the course topics and methods issues.

- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- apply life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management

- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation for companies
- The concept of 'continuous Improvement', and its application to environmental management
- Life Cycle Costing, as part of Life Cycle Management
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), incl. practical examples of companies.
- single score environmental assessment methods, with a focus on the 'ecopoints' method
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small homework exercises to apply the course topics and methods issues.

- define, plan, conduct and present a SciML project.
- incorporate scientific domain knowledge in the SciML process.
- define, plan, conduct and present a SciML project.
- incorporate scientific domain knowledge in the SciML process.
- define, plan, conduct and present a SciML project.
- incorporate scientific domain knowledge in the SciML process.

Upon completion of the course, the students will be able to:
1. Understand main ML background theory and methods.
2. Assess a problem and apply ML and DL in a computational framework accordingly.
3. Incorporate scientific domain knowledge in the SciML process.
4. Define, plan, conduct and present a SciML project.

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Suggested Reading:
- S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016
- A. E. Braunschweig - Sustainability problems of the current economic system and its measuring units; 2 credits

Familiarity with Python is advised.

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic will profit more from this course after reading an appropriate textbook before or at the beginning of this course, e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2).
This course provides an in-depth analysis of both the theoretical underpinnings to different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.

**Objective**

The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

**Content**

Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it; making sure that emissions of greenhouse gases (GHGs) stop within the next 20 to 30 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It’s a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

**Literature**

There will be reading assignments for select classes. All of these will be posted in PDF format on a course Moodle. In addition, there will be one book and one report to be read over the course of the semester. They are:

- Ministry of the Future, by Kim Stanley Robinson
- Ten Principles for Policy Making in the Energy Transition, by Laura Diaz Anadon et al.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories

- **Method-specific Competencies**
  - Analytical Competencies

- **Social Competencies**
  - Communication

- **Personal Competencies**
  - Critical Thinking

---

**701-1563-00L Climate Policy**

**W** 6 credits 4G

**Abstract**

This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.

**Objective**

Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course is to give a compact introduction into basics of Thermodynamics: Thermodynamic states and thermodynamic processes; Work and Heat; First and Second Laws of Thermodynamics. Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to building up students' intuition about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibrium. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included.

In the course "Energy Conversion", the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories

- **Method-specific Competencies**
  - Analytical Competencies

- **Social Competencies**
  - Communication

- **Personal Competencies**
  - Critical Thinking

---

**151-1633-00L Energy Conversion**

**W** 4 credits 3G

**Abstract**

This course is intended for students outside of D-MAVT.

This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.
Content
1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

Lecture notes
Lecture slides and supplementary documentation will be available online.

Literature

Prerequisites / notice
This course is intended for students outside of D-MAVT.

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

052-1205-24L Seminar Week Autumn Semester 2024
W 2 credits 3A
Lecturers
Abstract
The seminar week is obligatory for students of all semesters. There are many and varied study contents.

Objective
The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.

063-0805-24L History and Theory in Architecture IX: 1990s Theories that Inspired Architecture
W 1 credit 1V
C. Nuijsink

Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies

Method-specific Competencies
- Media and Digital Technologies
- Communication

Social Competencies
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

052-0639-24L Climate Responsive Architecture with Hive
W 1 credit 2G
A. Schlüter, E. Borkowski

Abstract
This Online course provides an introduction to climate-responsive design using the Hive tool and how to apply it in early building design stages. Hive allows architecture and building science students to understand the relation between architectural design, climate, comfort and energy. Hive is a plugin for the 3D modeling environment Rhino and its visual programming interface Grasshopper.

Objective
- Recall general principles of climate responsive design and examples of it.
- Utilize 3D building geometries to conduct simplified energy demand and supply simulations.
- Observe relevant physical principles and interactions between climate, energy and geometry.
- Implement passive and active concepts for Climate Responsive Design.
- Apply Hive for building design analysis and integrate it into own designs or in design courses.
- Identify and harness synergies and trade-offs between climate, energy and architectural design aspects.
Adaptability and Flexibility

The semester project is designed to train students in solving specific research questions in the field of integrated building systems. During the integrated design studio students work on a selected integrated architectural / urban design project, considering both energy and climate systems on both the urban and building scale and evaluate their interactions and impact on building design and operation. Retrieving relevant concepts and technologies of energy and HVAC systems, students are able to develop and compare integrated concepts using appropriate methods and digital toolsets and present them to a mixed audience using drawings, renderings and reports. A working Rhino 6 or 7 license is necessary.

Can architecture, urban design and planning contribute to housing reconstruction after conflicts and natural disasters? Answers to this question will be provided by researchers and socially engaged architects from Europe, Asia and Latin America through the presentation of concrete case studies and projects.

The current war in Ukraine and the recent earthquake in Turkey and Syria are dramatic reminders about the plight of the millions of people rendered homeless by manmade and natural disasters. Reconstruction after such tragic events requires the support of a large number of architects, urban planners and other built environment professionals with a thorough understanding of the specific issues and challenges entailed in working for and with affected communities. Based on concrete examples and extensive international field experience, the elective course will introduce students to the advantages and risk of different reconstruction approaches, with a specific focus on the links between housing reconstruction policies and community empowerment. A selected number of guest speakers from different countries will present concrete community-driven reconstruction initiatives from across the globe. The elective course aims at raising awareness among students about the complexity of housing reconstruction after disasters and is oriented in particular to those interested in a professional career in the humanitarian sector. The detailed program and recommend readings will be presented at the beginning of the course. A bibliography will be made available to inscribed students prior the start of the semester.

Prerequisites / notice

This is a blended-learning self-paced ONLINE COURSE that can be started at any time. A working Rhino 6 or 7 license is necessary.

Project Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>066-0425-00L</td>
<td>Integrated Design MIBS</td>
<td>O</td>
<td>6</td>
<td>3+V</td>
<td>A. Schütler, M. Meshkin Kiyas, Z. Shi</td>
</tr>
</tbody>
</table>

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>066-0431-00L</td>
<td>Semester Project MIBS</td>
<td>O</td>
<td>6</td>
<td>13A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1474 of 2667
Master's Thesis

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;

b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Master thesis are supervised and reviewed by one or several professors and possibly by other persons at the same time. At least one professor has to be a member of a department involved in the study programme (article 2). This regulation is also valid for master thesis taking place outside ETH Zurich.

Abstract
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking.

Objective
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking.

Content
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking. The thesis can be performed either at ETH Zurich, an industrial enterprise, or in a research institution, but has to be advised by one or more professors affiliated with the Master program "Integrated building systems".

The responsible supervisor defines the topic in consultation with the student, together with the scope of work, criteria of assessment, and dates of beginning and delivery of the work.

Integrated Building Systems Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
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</tr>
</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Interdisciplinary Sciences Bachelor

#### Physical-Chemical Direction

#### 1. Semester (Physical-Chemical Direction)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10 credits</td>
<td>6V+3U</td>
<td>L. Kobel-Keller</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.

**Objective**
The ability to work with the basics of calculus in a mathematically rigorous way.

**Literature**

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>S. Zerbes</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
- Mastering basic concepts of Linear Algebra
- Introduction to mathematical methods

**Content**
- Basics
- Vector spaces and linear maps
- Systems of linear equations and matrices
- Determinants
- Endomorphisms and eigenvalues

**Lecture notes**
Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester.

**Literature**

In addition we recommend this general introduction into studying mathematics:

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-1701-00L</td>
<td>Physics I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>K. Ensslin</td>
</tr>
</tbody>
</table>

**Abstract**
This course gives a first introduction to Physics with an emphasis on classical mechanics.

**Objective**
Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0011-01L</td>
<td>General Chemistry (Physical Chemistry) I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. J. Wörner</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.
Objective
After the lecture, students will be able to,
- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- analyze and calculate absorption and emission spectra of single-electron atoms,
- to set up the Schrödinger equation for a molecular multi-particle system,
- independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems,
- model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model,
- explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom,
- explain the structure of the periodic table of elements with the help of the orbital concept,
- recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and
- establish term symbols for atomic ground states.
Translated with www.DeepL.com/Translator (free version)

Content
Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

Lecture notes
See homepage of the lecture.

Literature
See homepage of the lecture.

Prerequisites / notice
Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Title</td>
<td>Type</td>
<td>ECTS</td>
</tr>
<tr>
<td>529-0011-04L</td>
<td>Practical Course General Chemistry</td>
<td>O</td>
<td>8 credits</td>
</tr>
</tbody>
</table>

Information about the practical course will be given on the first day.

Abstract
The general chemistry practical course aims at preparing the students for the work in modern chemistry laboratory. The students are trained to behave safely in the laboratory and use chemicals, chemistry glassware, and related equipment to perform and analyze the equilibrium in basic chemical reactions.

Objective
The students are expected to gain practical experience with as well as establish understanding of the following concepts and phenomena:
- Safe behavior and safety regulations in chemistry laboratory;
- Best practices in common techniques (purification, recrystallization, distillation, etc.);
- Analysis of measured values (measuring error, average value, error analysis);
- Acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems);
- Precipitation equilibria (gravimetry, potentiometry, conductivity measurements);
- Oxidation state and redox reactions (redox-titrations, galvanic elements);
- Metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration)
- Qualitative analysis (cation and anion separation, determination of cations and anions).

Content
In the general chemistry practical course students are introduced to the work in chemistry laboratory. During the course they become familiar with common chemistry glassware and related equipment as well as learn basic experimental procedures, such as distillation, recrystallization, purification, digestion etc. Upon the measurements of pH, conductivity, and potential in the course of reactions, students establish the understanding of the chemical equilibrium concept.

Students work with various classes of inorganic compounds and types of chemical reactions, e.g. acid-base, redox, precipitation. They also obtain first experience with the synthesis of metal complexes as well as learn basics of qualitative analysis of an unknown substance.

Literature
Moodle Lernplattform

Prerequisites / notice
Compulsory: online enrolment latest one week after start of the semester

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.

<table>
<thead>
<tr>
<th>Competencies</th>
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<th>Concepts and Theories</th>
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<tbody>
<tr>
<td>Number</td>
<td>Title</td>
<td>Type</td>
</tr>
<tr>
<td>529-0011-04L</td>
<td>Practical Course General Chemistry</td>
<td>Concepts and Theories</td>
</tr>
</tbody>
</table>

Autumn Semester 2024
**General Chemistry (Inorganic Chemistry) I**

**W+** 3 credits 2V+1U  A. Togni

**Objective**
Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective

**Content**
Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility

**Lecture notes**
Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.

**Literature**

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**General Chemistry (Organic Chemistry) I**

**W+** 3 credits 2V+1U  P. Chen

**Objective**
Introduction to the structures of organic compounds as well as the structural and energetic basis of organic chemistry.

**Content**
Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topicity, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intramolecular interactions.

**Lecture notes**
Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt

**Literature**

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### 3. Semester (Physical-Chemical Direction)

#### Examination Block

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>R. Signorell</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
Introduction to Chemical Reaction Kinetics

**Content**

**Lecture notes**
Will be provided

**Literature**

**Prerequisites / notice**
Voraussetzungen:
- Mathematik I und II
- Allgemeine Chemie I und II
- Physikalische Chemie I

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-2883-00L</td>
<td>Physics III</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>S. Johnson</td>
</tr>
</tbody>
</table>

**Abstract**
Introductory course on quantum and atomic physics including optics and statistical physics.

**Objective**
A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.
Einführung in die Quantenphysik: Planck'sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrsche Atommodell, de-Broglie Materiewellen.

Optik/Wellenoptik: Linsen, Abbildungssysteme, Brechung und Fermatsches Prinzip, Beugung, Interferenz, Fabry-Perot, Interferometer, Spektrometer.

Quantenmechanik: Dualismus Teilchen-Welle, Wellenfunktionen, Operatoren, Schrödinger-Gleichung, Potentialstufe und Potentialkasten, harmonischer Ozillator


Lecture notes
Im Rahmen der Veranstaltung werden die Folien in elektronischer Form zur Verfügung gestellt. Ergänzendes Buch wird als Pflichtlektüre empfohlen. Es wird kein Skript in der Vorlesung verteilt.
Wir werden die Quantenmechanik anhand der Schrödinger-Gleichung mit den klassischen elektro-magnetischen Wellen vergleichen. Zu den klassischen Wellen werden Ergänzungsunterlagen verteilt.

Literature
M. Alonso, E. J. Finn
Quantenphysik und Statistische Physik
R. Oldenbourg Verlag, München
5. Auflage
ISBN 978-3-486-71340-4

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

Electives
The Bachelor's programme in Interdisciplinary Sciences allows students to choose from any subject taught at a Bachelor level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the 2nd year. See the Programme Regulations 2018 for further details.

Number Title Type ECTS Hours Lecturers
252-0847-00L Computer Science W 5 credits 2V+2U M. Fischer, F. Friedrich Wicker

Abstract
The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

Objective
Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.

Content
The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

Lecture notes
Lecture slides and all other material will be made available for download on the course web page.

Literature
Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered

Social Competencies
Communication fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

401-2303-00L Complex Analysis W 6 credits 3V+2U Ö. Imamoglu

Abstract
Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.

Objective
Working knowledge of functions of one complex variables; in particular applications of the residue theorem.
### Literature

**B. Palka:** "An introduction to complex function theory."


**E.M. Stein, R. Shakarchi:** Complex Analysis. Princeton University Press, 2010

**Th. Gamelin:** Complex Analysis. Springer 2001

**E. Titchmarsh:** The Theory of Functions. Oxford University Press

**D. Salamon:** "Funktionentheorie". Birkhauser, 2011. (In German)


**K. Jaenich:** Funktionentheorie. Springer Verlag

**R. Remmert:** Funktionentheorie I. Springer Verlag

**E. Hille:** Analytic Function Theory. AMS Chelsea Publications

### Courses

#### 401-2333-00L Mathematical Methods of Physics I

**W** 6 credits 3V+2U  P. Hintz

**Abstract**


#### 402-0205-00L Quantum Mechanics I

**W** 8 credits 3V+2U  M. Krstic Marinkovic

**Abstract**


Applications: simple potentials in wave mechanics, scattering and resonance, harmonic oscillator, hydrogen atom, and perturbation theory.

**Objective**

Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

**Content**

The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.

**Lecture notes**

Auf Moodle

**Literature**

G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics

#### 402-0255-00L Introduction to Solid State Physics

**W** 8 credits 3V+2U  A. Zheludev

**Abstract**

The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, and magnetism.

**Objective**

Introduction to Solid State Physics.

**Content**

The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, thermal properties of insulators; metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism.

**Lecture notes**

The script will be available on moodle.

**Literature**

C. Kittel, Festkörperphysik
Ashcroft & Mermin, Festkörperphysik

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1480 of 2667
Astrophysics I

**W 8 credits 3V+2U**

A. Refregier

**Abstract**

This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.

**Objective**

The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.

**Literature**

Astrophysics for physicist, Arnab Ray Choudhuri

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered
- Method-specific Competencies
  - Analytical Competencies: assessed
- Personal Competencies
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered

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402-0595-00L

**Semiconductor Nanostructures**

**W 6 credits 2V+1U**

T. M. Ihn

**Abstract**

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

**Objective**

At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

**Content**

1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

**Lecture notes**


**Literature**

In addition to the lecture notes, the following supplementary books can be recommended:


**Prerequisites / notice**

The lecture is suitable for all physics students, students of Quantum Engineering, and students of Micro- and Nanosystems beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitious students in the third year of Physics may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered
- Method-specific Competencies
  - Analytical Competencies: assessed
- Social Competencies
  - Communication: fostered
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: fostered
- Personal Competencies
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-direction and Self-management: fostered

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402-2203-01L

**Classical Mechanics**

**W 7 credits 4V+2U**

M. Gaberdiel

**Abstract**

A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

**Objective**

Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed

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529-0051-00L

**Analytical Chemistry I**

**W 3 credits 3G**

D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi

**Abstract**

Introduction into the most important spectroscopical methods and their applications to gain structural information.
Objective Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Content Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.
UV/VIS spectroscopy: Basics, interpretation of electron spectra. Circular dichroism (CD) and optical rotation dispersion (ORD).

Lecture notes Script will be for the production price

- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5, überarbeitete Auflage, Thieme, Stuttgart, 1995
- E. Pretsch, P. Bühlmann, C. Affolter, M. Badertscher, Spektroskopische Daten zur Strukturaufklärung organischer verbindingen, 4, Auflage, Springer, Berlin/Heidelberg, 2001-

Prerequisites / notice Excercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 “Instrumental analysis of organic compounds” (4th semester) is recommended.
Students are able
- to explain the physical structure and chemical composition of the atmosphere
- to quantitatively describe and understand the fundamental physical and chemical process in the atmosphere
- to explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.

In the course "Atmospheric Physics", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined.

The students are able
- to interpret precipitation radar images
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; northatlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes

- to explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; northatlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

- to explain the mechanisms of convective storm formation using knowledge of thermodynamics and cloud microphysics.
- to interpret precipitation radar images
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, especially prediction of showers and severe convective storms, and optical phenomena

Students also learn to use thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in radiosonde ascents. Atmospheric mixing processes are introduced as a basis for fog formation. The concept of an air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.
Analytical Competencies

Practical Course General Chemistry

Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial

The students are expected to gain practical experience with as well as establish understanding of the following concepts and phenomena:

ECTS

12P

assessed

Polybook

Lecturers

assessed

fostered

assessed

fostered

Lohmann, U., Lüönd, F. and Mahrt, F., An Introduction to Clouds: The general chemistry practical course aims at preparing the students for the work in modern chemistry laboratory. The students are expected to gain practical experience with as well as establish understanding of the following concepts and phenomena:

Lecture notes

- Polybook


Prerequisites / notice

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

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<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
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<td>Problem-solving</td>
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<td>Self-direction and Self-management</td>
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<td>Critical Thinking</td>
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701-0501-00L Pedosphere W 3 credits 2V R. Kretzschmar

Abstract

Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.

Objective

Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

Content

Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.

Prerequisites / notice

Prerequisites: Basic knowledge in chemistry, biology and geology.

Literature

Polybook


752-4001-00L Microbiology W 2 credits 2V M. Schuppler, M. La Fortezza, M. Pilhofer, S. Robinson

Abstract

Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

Objective

Teaching of basic knowledge in microbiology.

Content


Literature

Wird von den jeweiligen Dozenten ausgegeben.

Competencies

Subject-specific Competencies

Concepts and Theories | assessed
Techniques and Technologies | assessed

Method-specific Competencies

Analytical Competencies | assessed
Problem-solving | assessed

Personal Competencies

Critical Thinking | assessed
Self-direction and Self-management | assessed

Laboratory Courses, Semester Papers, Proseminars, Field Trips

Further laboratory courses must be applied for at the respective Director of Studies.

Number Title Type ECTS Hours Lecturers

529-0011-04L Practical Course General Chemistry O 8 credits 12P M. Bezdek, D. Dirin, T. Segawa, A. Yakimov

Latest online enrolment is 18.09.2023.

Information about the practical course will be given on the first day.

Abstract

The general chemistry practical course aims at preparing the students for the work in modern chemistry laboratory. The students are trained to behave safely in the laboratory and use chemicals, chemistry glassware, and related equipment to perform and analyze the equilibrium in basic chemical reactions.

Objective

The students are expected to gain practical experience with as well as establish understanding of the following concepts and phenomena:

- Safe behavior and safety regulations in chemistry laboratory;
- Best practices in common techniques (purification, recrystallization, distillation, etc.);
- Analysis of measured values (measuring error, average value, error analysis);
- Acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems);
- Precipitation equilibria (gravimetry, potentiometry, conductivity measurements);
- Oxidation state and redox reactions (redox-titrations, galvanic elements);
- Metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration)
- Qualitative analysis (cation and anion separation, determination of cations and anions).
Content

In the general chemistry practical course students are introduced to the work in chemistry laboratory. During the course they become familiar with common chemistry glassware and related equipment as well as learn basic experimental procedures, such as distillation, recrystallization, purification, digestion etc. Upon the measurements of pH, conductivity, and potential in the course of reactions, students establish the understanding of the chemical equilibrium concept.

Students work with various classes of inorganic compounds and types of chemical reactions, e.g. acid-base, redox, precipitation. They also obtain first experience with the synthesis of metal complexes as well as learn basics of qualitative analysis of an unknown substance.

Literature

Moodle Lernplattform

Prerequisites / notice

Compulsory: online enrolment latest one week after start of the semester

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.

Cometetencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered

Social Competencies

Communication fostered
Cooperation and Teamwork fostered

Personal Competencies

Adaptability and Flexibility fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

529-0129-00L

Inorganic and Organic Chemistry II

W 11 credits 16P V. Mougel

Abstract

Introduction to the experimental methods of Inorganic Chemistry

Objective

The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc. The synthesis, characterization and analysis of inorganic compound are a main topic. Special emphasis on experimental techniques of synthetic inorganic chemistry, in particular the safe handling of reactive and pyrophoric chemical and solvent purification and drying techniques.

Emphasis is given to scientific writing (experiment reports).

Content

Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra.

Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

Prerequisites / notice

- Passed Basisprüfung
- Passed Practical Course General Chemistry (1. Semester, 529-0011-04)
- Passed Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230) or Practical Course BCB II: Organic Chemistry (3. Sem. BSc BCB, 529-0016-00)
- Continuous Attendance of Course Inorg. Chemistry 1 (3. Sem. BSc BCB, 529-0121) and Analytical Chemistry 1 (3. Sem., 529-0015)

This class has a limited number of positions available. If necessary, access priority will be settled according to the results of the first-year examinations. Students that are not accepted following that rule will be given priority for the coming year registration.

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Customer Orientation fostered
Leadership and Responsibility assessed
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

5. Semester (Physical-Chemical Direction)

Laboratory Courses, Semester Papers, Proseminars, Field Trips

Further laboratory courses must be applied for at the respective Director of Studies.

Number Title Type ECTS Hours Lecturers
529-0450-00L Semester Project W 18 credits 18A Lecturers

Abstract

In a semester project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1485 of 2667
**Objective**

Students are accustomed to scientific work and they get to know one specific research field.

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<th>Number</th>
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<td>O</td>
<td>15</td>
<td>15D</td>
<td>Lecturers</td>
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</table>

**Abstract**

It completes the Bachelor program and consists of a scientific project carried out independently.

**Objective**

Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.

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**Biochemical-Physical Direction**

**1. Semester (Biochemical-Physical Direction)**

**Compulsory Subjects First Year Examinations**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>402-0043-00L</td>
<td>Physics I</td>
<td>O</td>
<td>4</td>
<td>3+1U</td>
<td>R. Grange</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.

**Objective**

The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

**Content**

Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids); Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).

**Lecture notes**

The lecture follows the book "Physics" by Paul A. Tipler.
The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that operate within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biology are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements


The newly conceived lecture is supported by scripts.
Subject-specific Competencies fostered

The general chemistry practical course aims at preparing the students for the work in modern chemistry laboratory. The students are

Analytical Competencies fostered

The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.

Concepts and Theories assessed

Communication fostered

The students are expected to gain practical experience with as well as establish understanding of the following concepts and phenomena:

Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

Critical Thinking fostered

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- analyze and calculate absorption and emission spectra of single-electron atoms,
- to set up the Schrödinger equation for a molecular multi-particle system,
- independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems,
- model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model.

Social Competencies

Communication fostered

Objective

Cooperation and Teamwork fostered

After the lecture, students will be able to,

Customer Orientation fostered

- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.

Self-presentation and Social Influence fostered

After the lecture, students will be able to,

Sensitivity to Diversity fostered

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.

Negotiation fostered

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.

Personal Competencies

Adaptability and Flexibility fostered

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.

Creative Thinking fostered

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.

Critical Thinking assessed

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.

Integrity and Work Ethics assessed

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.

Self-awareness and Self-reflection fostered

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.

Self-direction and Self-management assessed

- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- to calculate physical quantities and their units which are important for chemistry,
- to establish term symbols for atomic ground states.
In the general chemistry practical course students are introduced to the work in chemistry laboratory. During the course they become familiar with common chemistry glassware and related equipment as well as learn basic experimental procedures, such as distillation, recrystallization, purification, digestion etc. Upon the measurements of pH, conductivity, and potential in the course of reactions, students establish the understanding of the chemical equilibrium concept.

Students work with various classes of inorganic compounds and types of chemical reactions, e.g. acid-base, redox, precipitation. They also obtain first experience with the synthesis of metal complexes as well as learn basics of qualitative analysis of an unknown substance.

Literature
Moodle Lernplattform

Prerequisites / notice
Compulsory: online enrolment latest one week after start of the semester

By enrolling in the laboratory course, students confirm to study all safety information thoroughly and to follow instructions.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Adaptability and Flexibility fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

3. Semester (Biochemical-Physical Direction)

Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0373-00L</td>
<td>Mathematics III: Partial Differential Equations</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>N. Moshayedi</td>
</tr>
</tbody>
</table>

Abstract

Objective
Classical tools to solve the most common linear partial differential equations.

Content
1) Examples of partial differential equations
   - Classification of PDEs
   - Superposition principle

2) One-dimensional wave equation
   - D'Alembert's formula
   - Duhamel's principle

3) Fourier series
   - Representation of piecewise continuous functions via Fourier series
   - Examples and applications

4) Separation of variables
   - Solution of wave and heat equation
   - Homogeneous and inhomogeneous boundary conditions
   - Dirichlet and Neumann boundary conditions

5) Laplace equation
   - Solution of Laplace's equation on the rectangle, disk and annulus
   - Poisson formula
   - Mean value theorem and maximum principle

6) Fourier transform
   - Derivation and definition
   - Inverse Fourier transformation and inversion formula
   - Interpretation and properties of the Fourier transform
   - Solution of the heat equation

7) Laplace transform (if time allows)
   - Definition, motivation and properties
   - Inverse Laplace transform of rational functions
   - Application to ordinary differential equations

Lecture notes
See the course web site (linked under Lernmaterialien)

Literature

Additional books:
4) E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1,2,11,12,6)

For additional sources, see the course web site (linked under Lernmaterialien)
Fundamental concepts: rate laws, elementary reactions and composite reactions, molecularity, reaction order. Experimental methods in
chemical reaction kinetics.

529-0001-00L Introduction to Computer Science

529-0422-00L Physical Chemistry II: Chemical Reaction Kinetics

529-0221-00L Organic Chemistry I

529-0450-00L Semester Project

529-0400-00L Bachelor’s Thesis

Prerequisites / notice

Required background:

1) Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant
2) Multiple integrals: Riemann integrals in two or three variables, change of variables
2) Sequences and series of numbers and of functions
3) Basic knowledge of ordinary differential equations

Examination Block 2

529-0422-00L Physical Chemistry II: Chemical Reaction Kinetics

529-0221-00L Organic Chemistry I

529-0450-00L Semester Project

529-0400-00L Bachelor’s Thesis

5. Semester (Biochemical-Physical Direction)

Laboratory Courses, Semester Papers, Proseminars, Field Trips

Further laboratory courses must be applied for at the respective Director of Studies.

Bachelor’s Thesis

Bachelor’s Thesis

Bachelor’s Thesis
Second and Third Year Additional Subjects
The Bachelor’s programme in Interdisciplinary Sciences allows students to choose from any subject taught at a Bachelor level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the 2nd year. See the Programme Regulations 2018 for further details.

Other Electives ETH
Further combinations of compulsory elective subjects arising upon specific written request by the students and permission by the Director of studies.

Selection of courses from entire course catalogue of ETH, according to individual study plan

Science in Perspective
Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Language Courses
see Science in Perspective: Language Courses ETH/UZH

Interdisciplinary Sciences Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td></td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td></td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
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<tbody>
<tr>
<td>V</td>
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<td></td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Interdisciplinary Sciences Master

The Master's programme in Interdisciplinary Sciences allows students to choose from any subject taught at the Master's level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the Master's programme. See the Programme Regulations 2020 for further details.

Majors

The following list provides various Majors that can be chosen from: https://ethz.ch/content/dam/ethz/special-interest/chab/chab-dept/studies/documents/IN/WL_IN_SR19192101_EN.pdf

In addition it is possible to create an individual Major in accordance with the Programme Regulations (Art. 19 paragraph 3).

Selection of courses from entire course catalogue of ETH, according to individual study plan

General Courses

Selection of courses from entire course catalogue of ETH, according to individual study plan

Proseminars, Laboratory Courses, Research Projects and Sem. Papers

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0020-00L</td>
<td>Research Project</td>
<td>W</td>
<td>20 credits</td>
<td>20A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract

In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.

Objective

Students are accustomed to scientific work and they get to know one specific research field.

Selection of courses from entire course catalogue of ETH, according to individual study plan

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-1000-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>20 credits</td>
<td>43D</td>
<td>Professors</td>
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</tbody>
</table>

Duration of the Master's Thesis: 4 months.

Abstract

In the Master's thesis students prove their ability to independent, structured and scientific working. The Master's thesis is usually carried out in a core or optional subject area as chosen by the student.

Objective

In the Master's Thesis students prove their ability to independent, structured and scientific working.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-1000-30L</td>
<td>Master's Thesis</td>
<td>W</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
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</table>

Duration of the Master's Thesis 6 months, possible only with permission of the Director of Studies.

Abstract

In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is usually carried out in a core or optional subject area as chosen by the student.

Objective

In the Master Thesis students prove their ability to independent, structured and scientific working.

Interdisciplinary Sciences Master - Key for Type

| W+ | Eligible for credits and recommended |
| O  | Compulsory                           |
| W  | Eligible for credits                 |
| E- | Recommended, not eligible for credits |
| Z  | Courses outside the curriculum       |
| Dr | Suitable for doctorate               |
| P  | practical/laboratory course          |
| A  | independent project                  |
| D  | diploma thesis                       |
| R  | revision course / private study       |

Key for Hours

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Interdisciplinary Brain Sciences Master

► Core Modules

The Core Modules take place at University of Zurich: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Core-Modules.html

► Elective Core Modules

Courses listed here take place at ETH Zurich.

Further courses and a complete list of the Elective Core Modules can be found here: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Elective-Core-Modules.html

Please register for ETH-courses at ETH Zurich, for UZH-courses at UZH.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1414-00L</td>
<td>Current Topics in Brain Research (HS)</td>
<td>W</td>
<td>1 credit</td>
<td>1.5K</td>
<td>I. Mansuy, further lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Different national and international scientific guests are invited to present and discuss their actual scientific results.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>To exchange scientific knowledge and data and to promote communication and collaborations among researchers. For students: Critical discussion of current research. Students aiming at getting a credit point for this colloquium choose one topic and write a critical essay on the presented research topic.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Different scientific guests working in the field of molecular cognition, neurochemistry, neuromorphology and neurophysiology present their latest scientific results.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>no handout</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>no literature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Some of the seminars will be shared with the Institute of Neuroinformatics (INI) of UZH.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

| 376-1219-00L | Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions |
| Abstract    | Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system. |
| Objective   | Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution. |
| Content     | This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order. |
|             | Introduction, problem definition, overview         |
|             | Rehabilitation of visual function                  |
|             | - Anatomy and physiology of the visual sense       |
|             | - Technical aids (glasses, sensor substitution)    |
|             | - Retina and cortex implants                        |
|             | Rehabilitation of hearing function                 |
|             | - Anatomy and physiology of the auditory sense     |
|             | - Hearing aids                                      |
|             | - Cochlea Implants                                  |
|             | Rehabilitation and use of kinesthetic and tactile function |
|             | - Anatomy and physiology of the kinesthetic and tactile sense |
|             | - Tactile/haptic displays for motion therapy (incl. electrical stimulation) |
|             | - Role of displays in motor learning               |
|             | Rehabilitation of vestibular function              |
|             | - Anatomy and physiology of the vestibular sense   |
|             | - Rehabilitation strategies and devices (e.g. BrainPort) |
|             | Rehabilitation of vegetative Functions             |
|             | - Cardiac Pacemaker                                 |
|             | - Phrenic stimulation, artificial breathing aids    |
|             | - Bladder stimulation, artificial sphincter        |
|             | Brain stimulation and recording                     |
|             | - Deep brain stimulation for patients with Parkinson, epilepsy, depression |
|             | - Brain-Computer Interfaces                        |
Literature

Introductory Books:


Selected Journal Articles and Web Links:


VideoTact, ForeThought Development, LLC. http://my.exeepc.com/?dwysocki/videotac.html

Prerequisites / notice

Target Group:

Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich

Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies

Communication
Leadership and Responsibility

Personal Competencies

Creative Thinking
Critical Thinking
Integrity and Work Ethics

227-0971-00L Computational Psychiatry

W 3 credits 4S K. Stephan

Abstract

This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.

Objective

This course aims at bridging the gap between mathematical modellers and clinical neuroscientists by teaching computational techniques in the context of clinical applications. The hope is that the acquisition of a joint language and tool-kit will enable more effective communication and joint translational research between fields that are usually worlds apart.
This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/ for details.

227-0969-00L  
Methods & Models for fMRI Data Analysis  
W 6 credits 4V  K. Stephan

Abstract
This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

Objective
To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

227-1033-00L  
Neuromorphic Engineering I  
W 6 credits 2V+3U  T. Delbrück, G. Indiveri, S.-C. Liu, M. Payand

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements. Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

401-0625-01L  
Applied Analysis of Variance and Experimental Design  
W 5 credits 2V+1U  L. Meier

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs.

Literature

Prerequisites
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Competencies
Subject-specific Competencies: Concepts and Theories  assessed
Techniques and Technologies  assessed
Method-specific Competencies: Analytical Competencies  assessed
Decision-making  assessed
Personal Competencies: Critical Thinking  assessed

376-1661-00L  
Ethics of Life Sciences and Biotechnology  
W 3 credits 2V  A. Blasimme, E. Vayena

Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1495 of 2667
Objective

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.

Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

Competencies

Subject-specific Competencies  
Concepts and Theories  
Techniques and Technologies  
Analytical Competencies  
Media and Digital Technologies  
Problem-solving  

Method-specific Competencies  
Analytical Competencies  
Media and Digital Technologies  
Problem-solving  

Social Competencies  
Communication  
Cooperation and Teamwork  
Leadership and Responsibility  
Self-presentation and Social Influence  
Sensitivity to Diversity  

Personal Competencies  
Adaptability and Flexibility  
Creative Thinking  
Critical Thinking  
Integrity and Work Ethics  
Self-awareness and Self-reflection  

Internship

Further information: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Internship.html

Master's Thesis and Exam


Interdisciplinary Brain Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>O</th>
<th>W+</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory</td>
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<td>Dr</td>
</tr>
<tr>
<td>Eligible for credits and recommended</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
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<tr>
<td>Eligible for credits</td>
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<td></td>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>V</th>
<th>G</th>
<th>U</th>
<th>S</th>
<th>K</th>
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<tbody>
<tr>
<td>lecture</td>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<tr>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<td>colloquium</td>
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</tbody>
</table>

ECTS - European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Compulsory Basic Courses

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All basic courses (in terms of content and methodology linked to “Foundation Studio I”) must be completed.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
Lectures, exercises and excursions serve as an introduction to atmospheric sciences, soil science and hydrology. Students gain a broad vision of the cutting edge topics that are being researched and studied at the Department of Environmental Systems Science at ETH, Eawag, WSL a.o. This will be the base for a future dialog between the field of landscape architecture and the field of sciences.

Objective
Students acquire basic knowledge in atmospheric sciences, hydrology and soil science:

- Understanding basic chemical and physical processes in the atmosphere that influence weather and climate
- Fundamentals about the classification of soils, soil-forming processes, physical and chemical soil properties, soil biology and ecology, soil degradation and protection
- Knowledge of water balance, principles of integral water management and climatic factors in the field of hydrology

Students develop an understanding of the relevance of these topics in the field of landscape architecture. Temporal and physical scale, research methods, units of measurement, lexicon, modes of representation and critical literature form the framework for the joint discourse.

Content
The course unit consists of the three courses "Climate", "Soil" and "Water", which are organized in modules.

Module 1 “Climate”, 23.–27.09.2024
- Atmospheric dynamics: weather conditions, precipitation formation, weather forecast
- Carbon Cycle: atmospheric CO2 concentrations and its interaction with the physical climate system
- Land-climate dynamics: interaction between the land surface and the climate system
- Hydrology and water cycle: extreme precipitation, influence of climate change on the cryosphere
- Introduction to geology: formation of rocks, geologic times, structural geology

Module 2 “Soil”, 30.09.–04.10.24
- Introduction to soils: definition, function, formation, classification and mapping
- Soil physics: soil texture, soil structure, soil water potentials, hydraulic conductivity
- Soil chemistry and fertility: clay minerals and oxides, cation exchange capacity, soil pH, essential plant nutrients
- Soil biology and ecology: soil fauna and microflora, fungi, bacteria, food web, organic matter
- Soil degradation and threats to soil resources: erosion, compaction, sealing, contamination, salinization

Module 3 “Water”, 11.11.–15.11.2024
Basics:
- Water supply: water balance, groundwater, water quality (water protection)
- River restoration
- Flooding, evapotranspiration/cooling of landscapes
- Hydropower (everything is managed - lake levels, water flows, pumping) - hydrology in the anthropocene
- Water management and storage

Lectures and notes
Course material will be provided.

Literature
The course material includes a reading list.

Prerequisites / notice
The courses "Climate", "Water" and "Soil" are organized with the Fundamental Studio I as joint one-week modules. The weekly schedules will be provided with the course materials.

Module 1 “Climate”, 23.–27.09.2024
Module 2 “Soil”, 30.09.–04.10.24
Module 3 “Water”, 11–15.11.2024

- The courses are held in English
- The written session examination covers all three courses “Climate”, “Soil” and “Water”.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed

Social Competencies
- Communication assessed

Personal Competencies
- Cooperation and Teamwork assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed

061-0103-00L Plant Ecology

Abstract
This course introduces plant ecology. Through lectures, exercises and excursions, students will gain a broad vision of the cutting edge topics that are being researched and studied at the Department of Environmental Systems Science at ETH and WSL. This will be the base for a future dialog between the field of landscape architecture and the field of sciences.

Objective
Students acquire basic knowledge in plant ecology focusing in its application in the field of landscape architecture. Temporal and physical scale, research methods, units of measurement, lexicon, modes of representation and critical literature form the framework for the joint discourse.
The fundamental course “Plant Ecology” is an introduction to the field of living systems, starting with the history of ecology, followed by an introduction to plant physiology. The course will also introduce students to the specifics of the rhizosphere, disturbance ecology and forests. Lastly, the course will focus on the specifics of tree structure and function.

Module 5 “Plant Ecology”, 28.10.–08.11.2024

The course is held in English.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
</tr>
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<td>Media and Digital Technologies</td>
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</tbody>
</table>

Social Competencies

| Communication | Cooperation and Teamwork |

Personal Competencies

<table>
<thead>
<tr>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrity and Work Ethics</td>
<td>Self-awareness and Self-reflection</td>
</tr>
</tbody>
</table>

Content

The module is divided into different subject areas:

1) Consolidation of botanical terms. These form the basis for the identification and recognition of plants. The most important technical terms are explained and illustrated with suitable plant material.

2) Species knowledge is taught on regular field excursions and supplemented with theoretical input. The species can also be studied in the classroom using fresh material. In addition to site characteristics and seasonal changes, growth forms are also taught.

3) Through the introduction to identification, the students will understand how a simple identification key is constructed and how it is used, so that unknown species can be identified independently.

4) Besides the species knowledge the students will get a basic introduction into systematic botany to better navigate through the content of this week.

5) Making sketches enables close observation of the structures and shapes of leaves.

Objective

Students will be introduced to botany and after the course they will be able to identify about sixty native trees and shrubs in order to use them appropriately in their designs. They will be familiar with botanical terms, which will enable them to understand information written in botanical literature.

Content

This course focuses on excursions with a botanical expert. In addition, the students are supported by theoretical and conceptual lectures. This gives the students a good basis of botanical knowledge, which can be professionally integrated into their designs.

Materials and Construction I

Focused on ground materiality, this course explores constructed potentials of working with biotic and abiotic materials, and techniques for modifying ground conditions. The shape and properties of the ground are fundamental for water movement, vegetative growth and microclimatic conditions on site. Learning the mechanisms for transforming earth’s surface opens up site-based design possibilities.

Students learn comprehensive skills for reading and modifying topography, soil and water, and for working with material life-cycles, behaviors and qualities to define new potentials for the constructed ground.
Adaptability and Flexibility

Decision-making

Communication

Cooperation and Teamwork

Leadership and Responsibility

Sensitivity to Diversity

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Communication

Cooperation and Teamwork

Leadership and Responsibility

Sensitivity to Diversity

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

061-0109-00L

History and Theory of Landscape Architecture I

The course deals with phenomena, terms and social contexts of designing nature since the 19th century, in order to derive a basis for ways of thinking and action for the present.

Students acquire an overview of the history of landscape architecture as well as an insight into the changing concepts and ways of thinking about designing nature. They become familiar with historical developments and their actuality and learn "from history". Students also analyse examples and design contexts and develop a basis for ways of thinking and action for current landscape architectural proposals.

Designing nature accompanies the history of mankind. Since industrialisation and with the establishment of landscape architecture as a profession, the understanding of nature and design concepts have changed from the green lung of cities to the current saving of the planet in the Anthropocene. The course deals with the relevant phenomena of designing nature (park, garden city, garden reform, new gardens, modern gardens, natural gardens, postmodern parks and landscapes, ecosystem repair, urban agriculture, slum upgrading, nature-cultures, etc.), terms (nature, landscape, garden, ecology, agriculture, etc.) and their wider contexts. Based on the history and theory of the profession, students develop a strong fundament for designing in the present.

The course material includes a reading list.

The course takes place as a block course alternating with "Ethics in Landscape Architecture".

The detailed course schedule is provided at the beginning of the semester and is included in the reader.

Course dates:
8:45 - 11:30:
14.10; 15.10; 16.10; 17.10; 18.11; 19.11; 20.11; 21.11
8:45 - 12:30:
18.10; 22.11

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Communication

Cooperation and Teamwork

Leadership and Responsibility

Sensitivity to Diversity

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

061-0111-00L

Ethics in Landscape Architecture

This course covers basic positions of philosophical ethics with a strong emphasis on central debates in landscape architecture.

The course aims to provide basic knowledge of concepts and terms within moral philosophy; engage with current debates in landscape architecture through lectures, text analysis, discussions and presentations; develop an understanding of the relation between science/society/design as well as practice and theory; help establish one's own design attitude; provide tools for argumentation; put to practice scientific working methods.

Between the poles of theory and practice and through the development of a foundation in ethics, the students' sensitivity for ecological, political and social issues will be awakened and strengthened. In response to current issues touched upon in the disciplinary media or journalism, we will reflect upon the role of landscape architects in today's society as well as one's own individual attitude within the profession. The overall goal is for students to gain a critical understanding of a range of design approaches as well as an awareness of the specific role of design and design quality in the context of ethical debates.

Detailed information regarding the course will be communicated at the beginning of the semester.
Lecture notes

Course material will be provided.

Literature

The course material includes a reading list.

Prerequisites / notice

The course takes place as a block course alternating with "History and Theory of Landscape Architecture I".

Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

061-0113-00L Digital Design Methods I

Abstract

This course introduces digital design methods in landscape architecture from data acquisition and modelling, to simulation and visualization.

Objective

Students know the most relevant survey methods, landscape modelling tools as well as simulation and visualization techniques. They are able to use those methods independently in the following semesters and in practice.

Content

Based on a case study, the students work on the entire workflow of a landscape architectural project:

1. Survey
2. Modelling
3. Analysis, Simulation, Visualization

The case study will serve as a synthesis project where the students can apply their acquired skills. During the course, students are supported by an interdisciplinary team in the development of their case study. The case study will be conducted in teams of two students.

Lecture notes

Digital and physical learning material is provided throughout the course.

Core Courses

The core courses build on the basic courses and convey basic, broad knowledge in the core areas of landscape architecture in relation to design lessons. Some of the core courses are compulsory and some are freely selectable. Further details, in particular about taking these subjects, for performance assessments and for compensating for failed subjects, are regulated in Art. 27 and Art. 31 Paragraph 4.

Compulsory Core Courses

Courses are offered in Spring Semester.

Elective Core Courses

Number Title Type ECTS Hours Lecturers
052-0717-24L Territory of the City: Turin W 2 credits 2G to be announced

Abstract

The elective deals with current transformation processes of metropolitan landscapes in Europe and introduces landscape architecture design on a territorial scale. On the basis of cartographic analysis and field trips, students will develop concrete strategies for the urban landscape of the Città Metropolitana di Torino.

Objective

The elective introduces to the subject and complexity of the urbanized landscape and teaches the critical engagement with the challenges and potentials of current tendencies in Landscape Architecture. On the basis of a concrete study area, students examine the large-scale processes of reuse, reform and reinterpretation of metropolitan landscapes in Europe and develop new approaches and strategies on various scales. They become familiar with GIS as an analytical tool, model building as a design methodology and the representation of landscape through plans. They develop a project based on the perception of place, knowledge of landscape-architectonic typologies and conception of public space. The design process is accompanied by workshops, lectures, excursions, critiques and a workbook.
The elective course "Topology" in the Autumn Semester 2023 builds on a long-standing specialization in the spatial exploration of the landscape. We will embark the participants on a terrain that we shape through our own thoughts and actions, adopting different perceptual perspectives, supported by examples from art, literature, technology and history.

This elective course gives architecture students the opportunity to further develop their perception of space through a site-specific approach in the field of landscape architecture. The students will learn to use 3D point cloud technology and other spatial sensing technologies in order to analyze complex urban landscape and develop new ways of editing and representing these intertwined spaces.
Content

Students will document and analyze a case-study site to reveal its topological potentials and sensory qualities. This understanding will be gained through point cloud modeling and audiovisual composition. In particular, we will develop a new, comprehensive sectional model of a topologically interesting site situation. Students will become acquainted to working with point cloud models produced with laser-scanning. Through a series of steps, they will learn how a laser-scanning survey is conducted, how the raw data is processed, how point cloud models are assembled, what qualities these models can provide to analyze, explore and represent space as an audiovisual experience. Collected samples from the field will be assembled and built into an interactive application in the «Landscape Visualization and Modelling Lab». All software required is open source and can also be installed on private laptops, facilitating work from home if necessary.

Lecture notes

Literature will be provided during the course.

Prerequisites / notice

- The course is limited to 20 students (based on available computer stations)
- Students will work in groups of 2
- The lectures will be held in English, assistance in English and German
- The enrolment will be prioritized by the time of inscription and balanced between departments

Competencies

Subject-specific Competencies
- Concepts and Theories: fostered
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: assessed
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Sensitivity to Diversity: assessed

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed

Compensatory Course for Core Courses

In the first semester of the curriculum no compensation courses for compulsory courses offered.

Advanced Courses

In the first semester of the curriculum there are no main courses offered.

Design Studios

The design studios deal with problem and practice-related tasks on a local, regional, supra-regional, national and international level. Teaching of digital analysis, design and planning methods.

Foundation Studio I and II

- Fundamental Studio I: basic knowledge;
- Fundamental Studio II: Design tasks in the context of the contemporary landscape;

Number Title Type ECTS Hours Lecturers
061-0141-24L Foundation Studio I W 14 credits 26U T. Galí-Izard, C. L. Turett

Abstract

This course introduces a design methodology for landscape architecture that emphasizes the design of living systems and dynamic landscape processes in dialogue with the environmental sciences. With a focus on translating and synthesizing scientific information through rigorous drawing and critically engaging with the primary matter of landscapes, this course teaches core tools of the discipline.

Objective

This design studio builds on a series of precise exercises that translate and synthesize the scientific information learned in the linked fundamental module courses required by the MScLA program. Through these exercises, students acquire essential analytical and methodological skills to support design in the field of Landscape Architecture.

Content

The Foundation Studio I in the autumn semester 2024 focuses on the Klausenpass, a high mountain pass connecting the Swiss cantons of Uri and Glarus. Throughout the semester students translate the particular conditions of this peripheral and often extreme landscape, rigorously drawing local climatic, geologic, hydrological, pedological and vegetative processes, and situating these systems in a larger context. Working with this method of translation, students make design proposals that respond to the unique material and ecological potentials of the pass.

Course desk crits, pin-ups, site visits and reviews are generally scheduled in the afternoon, and are linked to the content covered in the lectures and other theoretical inputs from the morning fundamental course.

Lecture notes

The reader is handed out during the first week of the semester.

Literature

Relevant literature is included in the reader.
The weekly schedule is published at the beginning of the semester and is included in the reader.

Classes and critiques are held in English.

No course 21th-25th of October 2024 (seminar week).

8:50 - 11:30:
18.09; 19.09; 23.09; 13.11; 15.11; 25.11; 26.11; 27.11; 28.11; 02.12; 03.12; 04.12; 05.12; 09.12; 10.12; 11.12; 12.12; 17.12

8:50 - 12:30:
20.09; 04.10; 01.11; 29.11; 06.12; 13.12

15:45 - 18:30:
17.09; 24.09; 01.10; 29.10; 05.11; 12.11; 19.11; 26.11

12:45 - 18:30:
18.09; 23.09; 25.09; 30.09; 02.10; 14.10; 16.10; 17.10; 28.10; 30.10; 06.11; 11.11; 13.11; 18.11; 20.11; 21.11; 25.11; 27.11; 02.12; 03.12; 04.12; 09.12; 10.12; 11.12; 17.12

12:45 - 16:30:
19.09; 07.11

13:45 - 17:30:
04.10; 28.11; 06.12; 13.12

12:45 - 17:30:
15.11; 05.12; 12.12

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed
- Negotiation assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Advanced Studio

Complex design tasks involving social, topographical, hydrological and ecological issues.

Seminar Week and Internship Report

In MScLA at least one week of seminar must be completed. Furthermore, part of the course is a six-month internship in the field of landscape architecture, the achievements (work phases, learning success) must be documented in an internship report.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>061-0153-00L</td>
<td>Internship Report ♦</td>
<td>O</td>
<td>2 credits</td>
<td>4P</td>
<td>T. Galí-Izard</td>
</tr>
<tr>
<td>Abstract</td>
<td>Part of the course is a six-month internship in the field of landscape architecture. The internship should cover as many work phases as possible in the work of a landscape architect. The students prepare an internship report in which they describe the various internship activities in detail and reflect on the learning success.</td>
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<tr>
<td>Objective</td>
<td>The internship report should cover as many work phases as possible in the work of a landscape architect. The students prepare an internship report in which they describe the various internship activities in detail and reflect on the learning success.</td>
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</tr>
<tr>
<td>Content</td>
<td>Part of the course is a six-month internship in the field of landscape architecture. The internship should include as many work phases as possible in the work of a landscape architect. The students prepare an internship report in which they describe the various internship activities in detail and reflect on the learning success.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Internship report (of 6 months, within the field of landscape architecture). The report can be written in German or English language.</td>
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</table>

| 052-0151-24L | Seminar Week Autumn Semester 2024 ♦                | W    | 2 credits | 3S    | T. Galí-Izard |
| Abstract   | This seminar week will take place at the bottom of the Mississippi River in the landscape paradox of New Orleans, a city largely below sea level which continues to sink as the sea rises outside the levee walls which protect it. Through the lens of the Garden of the 21st Century, we will explore the potential of the city’s subtropical climate and deltaic soils to produce an urban forest. |
| Objective  | Throughout the week, we will explore the mechanisms which created the hyper-controlled drainage system of New Orleans, and the soil conditions which resulted from the massive restructuring of the landscape in the 20th century. We will pay particular attention to the city’s urban canopy, which was largely wiped out during a severe hurricane. By visiting the watery landscapes outside the city’s walls by canoe, we will imagine what might be possible for the regeneration of a city which is on the frontlines of climate breakdown—starting with a garden of trees. |
Prerequisites / notice
Details of travel, accomodations, and food will be communicated before registration of seminar week opens.
Contact: Bonnie-Kate Walker, bk.walker@arch.ethz.ch

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Assessed</td>
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<tr>
<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
<td>Assessed</td>
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<tr>
<td>Decision-making</td>
<td>Assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td>Fostered</td>
</tr>
</tbody>
</table>

Social Competencies

| Communication | Assessed |
| Cooperation and Teamwork | Fostered |
| Customer Orientation | Fostered |
| Leadership and Responsibility | Fostered |
| Self-presentation and Social Influence | Fostered |
| Sensitivity to Diversity | Assessed |
| Negotiation | Assessed |

Personal Competencies

| Adaptability and Flexibility | Assessed |
| Creative Thinking | Assessed |
| Critical Thinking | Assessed |
| Integrity and Work Ethics | Fostered |
| Self-awareness and Self-reflection | Assessed |
| Self-direction and Self-management | Fostered |

Science in Perspective

Courses of the "Science in Perspective" programme have to be completed (details see study guidelines Art. 27).

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ARCH

Master's Thesis

The master's thesis is the successful completion of the course. It confirms the ability to work independently in the field of landscape architecture and is tutored by D-ARCH professors (for details see Art. 30 of the study regulations).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract
The Master’s thesis is the completion of the study program. The students develop a solution to a problem and practice-oriented task in the field of landscape architecture. All students will share a common site and region, that they will address at a scale of their choice.

Objective
It is intended to demonstrate the students' ability to design their own work and is proof of the successful completion of their studies. The Master's thesis is supervised by professors of the D-ARCH. The processing time for the master's thesis is fourteen weeks.

Prerequisites / notice
The Master's Thesis in Landscape Architecture starts on 09 September and ends on 16 December 2024.

Landscape Architecture Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
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<tbody>
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<td>G</td>
<td>Lecture with exercise</td>
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<td>U</td>
<td>Exercise</td>
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<td>D</td>
<td>Diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>Revision course / private study</td>
</tr>
</tbody>
</table>

Key for Hours

Special students and auditors need special permission from the lecturers.

ECTS
European Credit Transfer and Accumulation System

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1504 of 2667
<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern, M. Rau</td>
</tr>
</tbody>
</table>

Abstract: This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Objective: Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content: Thematic Schwerpunkte:
- Lernen als Verhaltensänderung und als Informationsverarbeitung; Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:

Lecture notes: Folien werden zur Verfügung gestellt.

Literature:

Prerequisites: This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0242-06L</td>
<td>Cognitive Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
</tbody>
</table>

Abstract: This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective: - Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites: Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

Abstract: The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

Objective: - Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W DZ)</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>S. Maurer, P. Caprez, I. Sargenti</td>
</tr>
</tbody>
</table>

Abstract: In this class, students will learn concepts and skills for coping with psychosocial demands of teaching

Objective: (1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Markwalder</td>
</tr>
</tbody>
</table>

Abstract: Adressed to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport). This course unit can only be enroled after successful
Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar (ca. 16 h), 2) collaboration with elementary school teacher in a class (ca. 34 h, with approx. 50% spent in the elementary or middle school class and ca. 50% for preparation), and 3) final report (ca. 10 h). Registration implies participation in all 3 parts.

Students learn more about the potential and challenges of pupils. They get to know the early stages of knowledge as well as the development of pre-concepts of students in their subject area. The seminar with a phase of cooperation consists of three phases: In the block seminar, pre-concepts are discussed in their own subject as well as theoretical inputs from developmental and cognitive psychology. During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students’ level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

https://www.minterlink.ch/student

Subject Didactics and Professional Training

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-9005-00L</td>
<td>Mentored Work Subject Didactics Food Science</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>G. Kaufmann</td>
</tr>
</tbody>
</table>

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

**Abstract**

- They learn to assess pupils' work.
- They contribute to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- They learn the skills of the teaching trade.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

**Objective**

The aim is for the students

- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

**Content**

Thematic Schwerpunkte:


**Literature**

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

**Lecture notes**

Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

**Prerequisites / notice**

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
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</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-9020-00L</td>
<td>Teaching Internship Including Examination Lessons Food Science</td>
<td>W</td>
<td>6 credits</td>
<td>13P</td>
</tr>
</tbody>
</table>

The teaching internship can just be visited if all other courses of TC are completed.

Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

**Abstract**

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

**Objective**

- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Lecture notes
Dokument: schriftliche Vorbereitung für Prüfungslektionen.

Literature
Wird von der Praktikumslehrperson bestimmt.

Competencies
Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

Food Science TC - Key for Type

<table>
<thead>
<tr>
<th>Letter</th>
<th>Key for Type</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>Letter</th>
<th>Key for Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
This course is built on the holistic approach in sustainable food processing via the consideration of the total value chain. Selected
Provided in the lecture notes.

The aggregation of food material determines the appearance and performance of complex food systems as well as nutritional aspects. The
Part 1 of the course deals with global market trends, food technologies, food health benefits. Physical and chemical fundamental
assessed

Food Rheology

Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

Objective
The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

Content
Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

Lecture notes
Notes will be handed out during the lectures.

Physics of Food Colloids

In Physics of Food Colloids the principles of colloid science will be applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

Objective
The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Content
Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

Lecture notes
Notes will be handed out during the lectures.

Emerging Thermal and Non Thermal Food Processing

This course is built on the holistic approach in sustainable food processing via the consideration of the total value chain. Selected mechanical, biotechnological, thermal and non-thermal techniques for best biomass and energy use efficiency will be investigated. Focused technologies are new thermal processes, high pressure techniques, electroporation and different radiation based sources.

Objective
Understanding of selected emerging food processing concepts with focus on lower process intensity for healthy and high quality food production, waste reduction as well as biomass and energy use efficiency. Updates from academia and industry around new trends in food process development

Content
Emerging combined processes based on mechanical, thermal and non-thermal techniques, Multi hurdle technology concept for preservation. Extreme high temperature-short time processes, high pressure techniques, electroporation, radiation, Biorefineries based on emerging process elements. Ongoing industry initiatives

Lecture notes
Script will be distributed before the course via Moodle.
Critical Thinking

L. Meier

W+ Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis

5 credits assessed

ECTS

A script will be available.

Subject-specific Competencies


The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual

assessed

fostered

Visual Competencies

Creative Thinking

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear

assessed

Decision-making

Literature

Robert D. Axelrod, Julia Baumgartner, Michael Beyerer and Alexander Mathys. Experimental and simulation-based investigation of the

7 Credits assessed

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis


Educational Competencies

Problem-solving

7 Credits assessed

Social Competencies


Personal Competencies

Decision-making

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Literature


Mechanisms. Annual Review of Food Science and Technology, 11.


Sevenich R. & Mathys A. (2018). Continuous versus discontinuous Ultra-High-Pressure systems for food sterilization with focus on Ultra-

High-Pressure Homogenization and High-Pressure Thermal Sterilization: a review. Comprehensive Reviews in Food Science and Food

Safety 17(5), 646-652.


Hertwig C., Meneses N. & Mathys A. (2018). Cold atmospheric pressure plasma and low energy electron beam as alternative nonthermal

decontamination technologies for dry food surfaces: A review. Trends in Food Science & Technology 77, 131-142.


Bioresource Technology 265, 268-274.


pasteurization of tomato and watermelon juice: An energy comparison and life cycle assessment. Journal of Cleaner Production, 141, 514–

525.


of milk ultra-high pressure homogenisation. Journal of Cleaner Production, 142 (4), 2209–2217.


harnessing nanosecond pulsed electric field processing. Biotechnology Advances, 319, 124173.

Robert D. Axelrod, Julia Baumgartner, Michael Beyerer and Alexander Mathys. Experimental and simulation-based investigation of the

interplay between factor gradients following pulsed electric field treatments triggering whey protein aggregation. Journal of Food Engineering, vol. 340, pp. 111308

Methodology Subjects

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an

introduction will be held.

Competencies Subject-specific Competencies Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies Analytical Competencies assessed

Decision-making assessed

Problem-solving assessed

Social Competencies Communication fostered

Personal Competencies Communication fostered

Creative Thinking assessed

Critical Thinking assessed

Self-direction and Self-management assessed

Number Title Type ECTS Hours Lecturers

401-0625-01L Applied Analysis of Variance and Experimental Design W+ 5 credits 2V+1U L. Meier

Abstract Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.


Prerequisites / notice The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Competencies Subject-specific Competencies Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies Analytical Competencies assessed

Decision-making assessed

Critical Thinking assessed

Personal Competencies

401-0649-00L Applied Statistical Regression W+ 5 credits 2V+1U M. Dettling

Abstract This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

Lecture notes The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

A script will be available.
### Optional Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-3105-00L</td>
<td>Physiology Guided Food Structure and Process Design</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>P. A. Fischer, M. Devezeaux de Lavergne, B. von der Weid, T. Wooster</td>
</tr>
</tbody>
</table>

#### Abstract
A sound understanding of physiological implications of food design will allow to shape new products, which feature health as well as environmental benefits and on the other side do not compromise on organoleptic qualities, formulation and manufacturing, and quality and safety. The course links the physiological driven requirements with food structure design and subsequent engineering steps.

#### Objective
The objective of this course is to highlight the link between human physiology, product sensory, nutritional functions, and engineering approaches to facilitate the design of food matrixes reflecting the requirements for the beforementioned properties. To identify and manipulate these properties, the pathways that control the interaction of food structures and their physiological action will be introduced. Students are introduced to a skill set that will encompass basic digestion, sensory physiology knowledge, and food structures. Students will be exposed to the interplay along the gastrointestinal tract including taste, aroma, and texture perception, swallowing mechanics, and gastrointestinal digestion with an engineering or physical sciences angle.

#### Content
- Chapter 1: Introduction - The need for physiology guided structure and process design in the context of personalized nutrition (Peter Fischer)
- Chapter 2: Food Oral Processing: the impact of food oral breakdown on sensory perception (Marine Devezeaux de Lavergne)
- Chapter 3: Chewing and swallowing across the lifespan, from infants to elderly (Marine Devezeaux de Lavergne)
- Chapter 4: Perception physiology in humans and other species (Benot von der Weid)
- Chapter 5: Biophysics of food digestion & how it can be exploited in the development of strategies for delivery (Timothy J. Wooster)
- Chapter 6: Numerical and experimental modelling of the intestinal system (Peter Fischer)

#### Lecture notes
Lecture notes are available at Moodle

#### Competencies
- **Subject-specific Competencies**
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- **Method-specific Competencies**
  - Analytical Competencies assessed
  - Decision-making assessed
  - Media and Digital Technologies assessed
  - Problem-solving assessed
  - Project Management fostered
- **Social Competencies**
  - Cooperation and Teamwork fostered
  - Communication fostered
  - Customer Orientation fostered
  - Leadership and Responsibility fostered
  - Self-presentation and Social Influence fostered
  - Adaptability and Flexibility assessed
  - Critical Thinking assessed
  - Integrity and Work Ethics assessed
  - self-awareness and Self-reflection fostered
  - Self-direction and Self-management fostered

### Major in Food Quality and Safety

#### Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-0801-00L</td>
<td>Food Law and Legislation</td>
<td>W+</td>
<td>1 credit</td>
<td>1V</td>
<td>K. Krell Zbinden, E. Zbinden Kaessner</td>
</tr>
</tbody>
</table>

#### Abstract
Introduction to the principles of the EU and international Organisations, Set up and Application of the Swiss Food Law.

#### Objective
Knowledge of the principles and the structure of the EU in general and in the area of food safety, overview of the relevant bilateral agreements CH-EU as well as on the most important international organisations.

Basic knowledge of the structure of Swiss food law and its implementation in the context of self-controll in food companies. The process of food enforcement is known and issues can be assessed from a legal perspective.
The course offers detailed information on selected foodborne pathogens and toxin-producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!
A selection of approximately 20 papers from recent primary scientific literature.

The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).

The course is open to Masters or PhD level students.

For Masters level participants, a strict prerequisite is (a) previously taken and passed “Introduction to Toxicology” (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take "Special Topics in Toxicology", do not register at the same time for “Advanced Topics in Toxicology”. It is only possible to take one, and it is only possible to take the advanced level after completing this course.

### Methodology Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W+</td>
<td>5</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
<tr>
<td>Abstract</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.</td>
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<td>Competencies</td>
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<td></td>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
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<td>Personal Competencies</td>
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<td>Decision-making</td>
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<td>Critical Thinking</td>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W+</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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<tr>
<td>Abstract</td>
<td>This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning &quot;good practice&quot; that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.</td>
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<tr>
<td>Objective</td>
<td>The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.</td>
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<td>Content</td>
<td>The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.</td>
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<td>Lecture notes</td>
<td>A script will be available.</td>
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<tr>
<td>Literature</td>
<td>Faraway (2005): Linear Models with R</td>
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<td></td>
<td>Faraway (2006): Extending the Linear Model with R</td>
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<td>Draper &amp; Smith (1998): Applied Regression Analysis</td>
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<td>Fox (2008): Applied Regression Analysis and GLMs</td>
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<td>Montgomery et al. (2006): Introduction to Linear Regression Analysis</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.</td>
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In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.
### Applied Bioinformatics: Microbiomes

**ECTS:** 5 credits

**Course Type:** W

**Lecturers:** N. Bokulich, M. Ziemski

**Abstract:** Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

**Objective:** Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

**Content:**
1. Introduction to microbiomes and microbial bioinformatics toolkit. Python, Pandas, Jupyter, GitHub, visualization libraries for Python.
3. Microbial diversity, function, and ecology. Molecular ecology, diversity metrics, ordination methods.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

**Prerequisites / notice:** No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

Students will bring and work on their own laptop computers.

All software used in the course is free and open-source.

### Optional Subjects

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
752-1300-00L | Advanced Topics in Toxicology | W | 2 credits | 2G | S. J. Sturla

Only for students who have previously taken "Special Topics in Food Toxicology" (752-1301-00L).

**Abstract:** Journal-club style course that involves student presentations of selected topics in Toxicology on the basis of current primary research and review papers.

**Objective:** The goals are to stimulate student interest and provide advanced knowledge of current research in the interdisciplinary area of Food and Nutrition Toxicology and its related sciences. The student should develop skills in the critical evaluation of scientific literature, oral presentation and questioning, and understanding modern experimental techniques in Molecular Toxicology.

**Content:** The journal-club style course involves student presentations of recent publications. The primary focus is on chemical and biochemical aspects of selected topics in Toxicology. Participants are generally masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Pharmaceutical Sciences, etc.), and strong knowledge of organic chemistry and biochemistry are prerequisite. Selected course topics change every semester.

**Prerequisites / notice:** Participants are required to have completed previously "Special Topics in Toxicology" (752-1301-00L). Both courses are run concurrently every semester. It is only possible to register for one course at a time. Do not register for "Advanced Topics in Toxicology" until after you have completed "Special Topics in Toxicology"

376-1353-00L | Nanostructured Materials Safety | W | 2 credits | 1V | P. Wick, T. Bürki-Thurnherr

**Abstract:** Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.

**Objective:** Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.
Content
Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily live. These customized nanomaterials provides extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials.

The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications and intravenous injections as well as it will provide impulses for safer material designs.

Structure of the planned lecture (2 x 45 min)
1. Introduction: the principles of nanotoxicology
2. Lung- particles interactions: two disease scenarios and their molecular mechanism
3. GI – particles interactions: intendent and unintendent particle exposure via food
4. Skin – particles interactions: body care products and their influence on skin physiology
5. intravenous injection: colloidal stability, protein corona and cellular effects
6. Micro-/ Nanoplastics and development of a safety research plan
7. End of semester exam

Lecture notes
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website.

Prerequisites / notice
Course “Introduction to Toxicology”

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Problem-solving
Project Management
Communication
Cooperation and Teamwork

Major in Nutrition and Health
Disciplinary Subjects

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<td>752-2307-00L</td>
<td>Nutritional Aspects of Food Composition and</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>B. E. Baumer, J. M. Sych</td>
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<td>Processing</td>
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<td>Lecture type course with an interdisciplinary</td>
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<td>approach for the evaluation of nutritional aspects</td>
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<td>changes in food composition due to processing.</td>
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<td>Students should be able to</td>
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<td>- describe and compare the major concepts /</td>
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<td>criteria used for the evaluation of the</td>
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<td>nutritional quality of food</td>
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<td>- apply these criteria when assessing the effects</td>
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<td>of selected processing technologies on</td>
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<td>nutritional quality.</td>
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<td>- evaluate recent formulation strategies aimed</td>
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<td>to achieve additional physiological benefits</td>
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<td>for targeted population groups (i.e. functional</td>
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<td>foods).</td>
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<td>thermal/chilling, enzymatic, chemical,</td>
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<td>separation and emerging technologies) or new</td>
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<td>formulation strategies. New approaches for</td>
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<td>evaluating these changes (e.g. nutritional profiles)</td>
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<td>and how these are communicated to consumers are</td>
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<td>and relevant scientific articles will be available</td>
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<td>on-line for students. A selection of recommended</td>
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<td>readings will be given at the beginning of the</td>
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<td>Prerequisites / notice</td>
<td>The course is open to Master and MAS students in food and</td>
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<td>science and nutrition or related. Basic knowledge</td>
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<td>of food chemistry and nutrition is expected, as</td>
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<td>well as an understanding of food processing.</td>
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<td>752-6101-00L</td>
<td>Nutrition and Chronic Disease</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>F. von Meyenn, M. Andersson</td>
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<td>Abstract</td>
<td>To have the student gain understanding of the</td>
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<td>links between the diet and the etiology and</td>
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<td>progression of chronic diseases, including</td>
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<td>diabetes, gastrointestinal diseases, kidney</td>
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<td>disease, cardiovascular disease, arthritis and</td>
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<td>food allergies.</td>
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<td>To examine and understand the protective</td>
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<td>maintenance of health and the prevention of</td>
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<td>chronic disease, as well as the progression of</td>
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<td>complications of the chronic diseases.</td>
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<td>Content</td>
<td>The course evaluates food and food ingredients</td>
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<td>in relation to primary and secondary prevention</td>
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<td>of chronic diseases including diabetes,</td>
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<td>gastrointestinal diseases, kidney disease,</td>
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<td>cardiovascular disease, arthritis and food</td>
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<td>allergies.</td>
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<td>Lecture notes</td>
<td>There is no script. Powerpoint presentations</td>
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<td>will be made available on-line to students.</td>
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<td>Literature</td>
<td>To be provided by the individual lecturers, at</td>
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<td>their discretion.</td>
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<td>Prerequisites / notice</td>
<td>No compulsory prerequisites, but prior completion of the</td>
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<td>courses “Introduction to Nutritional Science”</td>
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<td>and “Advanced Topics in Nutritional Science”</td>
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<td>is strongly advised.</td>
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<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W+</td>
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<td>2V</td>
<td>M. Puhan, R. Heusser</td>
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<td>credits</td>
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<tr>
<td>Abstract</td>
<td>The module Epidemiology and prevention describes</td>
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<td>the process of scientific discovery from the</td>
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<td>detection of a disease and its causes, to the</td>
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<td>development and evaluation of preventive and</td>
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<td>treatment interventions and to improved population</td>
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<td>health.</td>
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<td>Objective</td>
<td>The overall goal of the course is to introduce</td>
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<td>students to epidemiological thinking and</td>
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<td>methods, which are critical pillars for medical</td>
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<td>and public health research. Students will also</td>
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<td>become aware on how epidemiological facts are</td>
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<td>used in prevention, practice and politics.</td>
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<tr>
<td>Content</td>
<td>The module Epidemiology and prevention follows an</td>
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<td>overall framework that describes the course of</td>
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<td>scientific discovery from the detection of a</td>
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<td>disease to the development of prevention and</td>
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<td>treatment interventions and their evaluation in</td>
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<td>clinical trials and real world settings. We</td>
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<td>will discuss study designs in the context of</td>
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<td>existing knowledge and the type of evidence</td>
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<td>needed to advance knowledge. Examples from</td>
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<td>nutrition, chronic and infectious diseases will</td>
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<td>be used in order to show the underlying concepts</td>
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<td>and methods.</td>
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### Methodology Subjects

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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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752-5500-00L Applied Bioinformatics: Microbiomes [W+] 5 credits 2V+2U N. Bokulich, M. Ziemski
Abstract
Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

Objective
Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

Content
1. Introduction to microbiomes and microbial bioinformatics toolkit. Python, Pandas, Jupyter, GitHub, visualization libraries for Python.
3. Microbial diversity, function, and ecology. Molecular ecology, diversity metrics, ordination methods.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice
No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

Students will bring and work on their own laptop computers.

All software used in the course is free and open-source.

Method-specific Competencies
Techniques and Technologies
assessed

Social Competencies
Communication
assessed

Personal Competencies
Critical Thinking
assessed

Software used in the course is free and open-source.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Creative Thinking
fostered

Critical Thinking
fostered

Self-direction and Self-management
fostered

Optional Subjects

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<tr>
<th>Number</th>
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<tr>
<td>752-6301-00L</td>
<td>Nutrition-Related Physiology</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>F. von Meyenn, E. Gasser</td>
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<td>752-6403-00L</td>
<td>Nutrition and Performance</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>S. Mettler</td>
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<td>752-1301-00L</td>
<td>Special Topics in Toxicology</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>K. Hecht, S. J. Sturla</td>
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</table>

Abstract
The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).
The course is open to Masters or PhD level students.

For Masters level participants, a strict prerequisite is (a) previously taken and passed "Introduction to Toxicology" (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take "Special Topics in Toxicology", do not register at the same time for "Advanced Topics in Toxicology". It is only possible to take one, and it is only possible to take the advanced level after completing this course.

### 752-2122-00L Food and Consumer Behaviour

**Abstract**
This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products.

**Objective**
Students will be able to:

- to describe heuristics that influence consumer behavior in the food domain
- to explain the consumer led food product development
- to summarise how consumers perceive the environmental impact and the healthiness of foods
- to assess the cultural, the environmental and the food policy impact on consumer behavior
- to explain psychological factors influencing eating behavior

**Competencies**

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<tr>
<th>Subject-specific Competencies</th>
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<td>Sensitivity to Diversity</td>
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### 766-6304-00L Nutrition Research Procedure

**Abstract**
This course provides students interested in nutrition with fundamental tools and concepts in human nutrition research, including topics such as study design, statistical analysis, scientific writing and communicating results. Preparation of a research proposal will consolidate student learning. The course is designed for MA and first semester MSc Nutrition and Health students.

**Objective**
This course will familiarise students with the fundamental concepts, methodologies and terminology that apply to human nutrition research. The course features both didactic presentations and in-class practical exercises including topics such as study design, statistics, scientific writing and communicating results. Students will have the opportunity to consolidate their learning by preparing a research protocol to study a nutrition-related health problem, which will be submitted for grading and presented in an end-of-semester graded poster presentation.

On completion of this course, students will have improved:

- Understanding of experimental study design in basic and clinical research
- Familiarity with the research process and methods used in human nutrition
- Understanding of basic statistics and analytical skills used in preparing and reporting research, including in tables and graphs
- Ability to report scientific results in writing and orally
- Skills in scientific writing and an understanding of the publication process
- Proficiency in retrieval and interpretation of scientific literature

**Lecture notes**
The teaching slides used in the lectures will be made available weekly on Moodle before each class, as pdf files.

**Literature**
There is no recommended textbook or prior reading required for this class. Students will be provided with recommendations for further reading where relevant, with the lecture notes.

**Prerequisites / notice**
Students are expected to attend and actively participate in the course, which includes the preparation of a research protocol that will be presented and graded during a poster presentation at the end of the semester.

**Competencies**

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### Major in Human Health, Nutrition and Environment

#### Module

#### Module Public Health

The module Public Health is compulsory for all students in the major Human Health, Nutrition and Environment.

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<td>401-0629-00L</td>
<td>Applied Biostatistics</td>
<td>W+</td>
<td>4</td>
<td>3G</td>
<td>M. Tanandin</td>
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<tr>
<td>Abstract</td>
<td>This course covers</td>
<td>the main methods used</td>
<td>in Biostatistics. It</td>
<td>starts</td>
<td>by revising</td>
</tr>
<tr>
<td>Objective</td>
<td>After this course</td>
<td>students:</td>
<td>- revised</td>
<td>Linear</td>
<td>Models</td>
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<tr>
<td></td>
<td>Content</td>
<td>This course is structured into three parts. The first part focuses on</td>
<td>Linear and</td>
<td>Generalised</td>
<td>Linear</td>
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<tr>
<td>Prerequisites</td>
<td>The statistical software R will be used in the exercises. If you are unfamiliar</td>
<td>with</td>
<td>R, it is highly</td>
<td>recommend</td>
<td>to</td>
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| 752-6105-00L | Epidemiology and Prevention | W   | 3    | 2V    | M. Puhan, R. Heusser |
Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Competencies
Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication

Personal Competencies
- Cooperation and Teamwork
- Critical Thinking

Assessed:
- Communication
- Problem-solving
- Project Management

Fostered:
- Analytical Competencies
- Decision-making
- Concept and Theories
- Cooperation and Teamwork
- Critical Thinking

ECTS
3 credits

Hours
2V

Lecturers
J. Jokela
F. Feijen
C. Vorburger
A. Hall
R. Heusser
W.

Module Infectious Diseases

Number
701-1703-00L
Title
Evolutionary Medicine for Infectious Diseases

Type
W

ECTS
3

Hours
2G

Lecturers
A. Hall

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases, for example in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) the evolutionary determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
The focus is on primary literature, but for some parts the following text books provide good background information:

- Schmid Hempel 2011 Evolutionary Parasitology
- Stearns & Medzhitov 2016 Evolutionary Medicine
- Schimzu & Medzhitov 2011 Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Competencies
Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Decision-making

Social Competencies
- Communication

Personal Competencies
- Cooperation and Teamwork
- Critical Thinking

Assessed:
- Communication
- Decision-making
- Concept and Theories
- Cooperation and Teamwork
- Critical Thinking

Fostered:
- Analytical Competencies

ECTS
3

Hours
1V+1P

Lecturers
F. Feijen
J. Jokela
C. Vorburger
A. Hall

Module Infectious Diseases

Number
701-1471-00L
Title
Ecological Parasitology

Type
W

ECTS
3

Hours
3V+1P

Lecturers
F. Feijen
J. Jokela
C. Vorburger

Abstract
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

Note:
Does not take place this semester.

Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research
Adaptability and Flexibility

Analytical Competencies assessed

Concepts and Theories fostered

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms

Obtain a detailed understanding of

Subject-specific Competencies

Method-specific Competencies

Social Competencies

Personal Competencies

Competencies

Prerequisites / notice

The three practicals will take place at the 03.10.2023, the 17.10.2023 and the 07.11.2023 at Eawag Dübendorf from 08:15 - 12:00. Note

that each practical takes 2 hours longer than the weekly lecture.

Lectures:

Prerequisites / literature

Immunology I and II recommended but not compulsory

Immunology III


Content

Abstract

This course provides a detailed understanding of

- development of T and B cells
- the dynamics of a immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective

Obtain a detailed understanding of

- the development, activation, and differentiation of different types of T cells and their effectormechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

Content

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the “Danger” concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature

Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Molecular Biology of Foodborne Pathogens

W 3 credits 2V M. Loesnser, A. Harms, M. Schuppeler, E. Slack

Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms

Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they

work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What

can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of

bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and

antimicrobial intervention.

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature

Recommendations will be given in the first lecture

Prerequisites / notice

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!
Module Nutrition and Health

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<tr>
<td>752-6101-00L</td>
<td>Nutrition and Chronic Disease</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>F. von Meyenn, M. Andersson</td>
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<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
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<tr>
<td>766-6304-00L</td>
<td>Nutrition Research Procedure</td>
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<td>3</td>
<td>2G</td>
<td>J. Rigutto</td>
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</table>

Abstract

- To have the student gain an understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

- To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

- The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, and food allergies.

- To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

- To provide a list of at least 10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition.
This course will familiarise students with the fundamental concepts, methodologies and terminology that apply to human nutrition research. The course features both didactic presentations and in-class practical exercises including topics such as study design, statistics, scientific writing and communicating results. Students will have the opportunity to consolidate their learning by preparing a research protocol to study a nutrition-related health problem, which will be submitted for grading and presented in an end-of-semester graded poster presentation.

On completion of this course, students will have improved:
- Understanding of experimental study design in basic and clinical research
- Familiarity with the research process and methods used in human nutrition
- Understanding of basic statistics and analytical skills used in preparing and reporting research, including in tables and graphs
- Ability to report scientific results in writing and orally
- Skills in scientific writing and an understanding of the publication process
- Proficiency in retrieval and interpretation of scientific literature

Lecture notes
The teaching slides used in the lectures will be made available weekly on Moodle before each class, as pdf files.

Prerequisites / notice
Students are expected to attend and actively participate in the course, which includes the preparation of a research protocol that will be presented and graded during a poster presentation at the end of the semester.

Competencies
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<td>Techniques and Technologies</td>
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Module Environment and Health

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<tr>
<td>376-1353-00L</td>
<td>Nanostructured Materials Safety</td>
<td>W</td>
<td>2</td>
<td>1V</td>
<td>P. Wick, T. Bürki-Thurnherr</td>
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Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

Content
Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily live. These customized nanomaterials provide extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials.

The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications and intravenous injections as well as it will provide impulses for safer material designs.

Structure of the planned lecture (2 x 45 min)
1. Introduction: the principles of nanotoxicology
2. Lung- particles interactions: two disease scenarios and their molecular mechanism
3. GI – particles interactions: intendent and unintendent particle exposure via food
4. Skin – particles interactions: body care products and their influence on skin physiology
5. intravenous injection: colloidal stability, protein corona and cellular effects
6. Micro-/ Nanoplastics and development of a safety research plan
7. End of semester exam

Lecture notes
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

Prerequisites / notice
course “Introduction to Toxicology”

Competencies
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<td>Cooperation and Teamwork</td>
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Term Paper

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Abstract
Writing of a review paper of scientific quality on a topic in the domain of Human Health, Nutrition and Environment based on critical evaluation of scientific literature.

Objective
- Acquisition of knowledge in the field of the review paper
- Assessment of original literature as well as synthesis and analysis of the findings
- Practising of academic writing in English
- Giving an oral presentation with discussion on the topic of the review paper

Content
Topics are offered in the domains of the major ‘Human Health, Nutrition and Environment’ covering ‘Public Health’, ‘Infectious Diseases’, ‘Nutrition and Health’ and ‘Environment and Health’.

Lecture notes
Guidelines will be handed out in the beginning.

Literature
Literature will be identified based on the topic chosen.
### Methodology Subjects

The courses are offered in the spring semester

### Minors

#### Food Biotechnology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-5105-00L</td>
<td>Biotechnology of Alcoholic Beverage Production</td>
<td>W+</td>
<td>2 credits</td>
<td>2V</td>
<td>R. Mira de Orduna Heidinger, N. Bokulich, M. Rienth</td>
</tr>
</tbody>
</table>

**Abstract**

This course introduces fundamental aspects of the production of beer and grape wine.

**Objective**

The objective of the course is to provide participating students with a sound understanding of the raw materials, microorganisms, microbial and chemical transformations and processing aspects involved in the production of beer and grape wine. Sensory aspects and product stability will also be considered.

**Content**

- Introduction of alcoholic beverage production within industrial microbiology
- Brewing
  - Raw materials, and malting
  - Brewhouse processes, wort production, fermentations, lagering
  - Sensory aspects and diacetyl management
- Winemaking
  - Grape growing and grape processing
  - Crush and pressing
  - Fermentations and microbial transformations
  - Fining, stabilizations, filtration and bottling
  - Aroma and macromolecule chemistry, climate change
  - Sensory aspects and wine faults

**Lecture notes**

Lecture handouts will be provided electronically. The lectures will not be recorded.

**Literature**

A list of learning materials will be provided online.

**Prerequisites / notice**

Students taking 752-5105-00L require a sound knowledge of basic chemistry, biochemistry, molecular genetics, microbiology and microbial physiology.

In order to decipher the costs of tastings, a financial participation of CHF25 will be required per student.

### Competencies

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Media and Digital Technologies: fostered
- **Social Competencies**
  - Communication: fostered
  - Cooperation and Teamwork: fostered
- **Personal Competencies**
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-direction and Self-management: assessed
### Food Chemistry

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0041-00L</td>
<td>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</td>
<td>W</td>
<td>6</td>
<td>G</td>
<td>R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano</td>
</tr>
</tbody>
</table>

#### Abstract
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

#### Objective
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

#### Content
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

#### Lecture notes
Lecture notes will be made available online.

#### Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

#### Prerequisites / notice
Exercises are an integral part of the lecture.

Prerequisites:
- 529-0051-00 "Analytische Chemie I (3. Semester)"
- 529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)
Food Microbiology

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<tbody>
<tr>
<td>752-4009-00L</td>
<td>Molecular Biology of Foodborne Pathogens</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Loessner, A. Harms, M. Schuppler, E. Slack</td>
</tr>
</tbody>
</table>

Abstract: The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective: Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content: Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Food Sensory Science and Consumer Behaviour

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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
</tr>
</tbody>
</table>

Abstract: This course focuses on food consumer behavior, consumer’s decision-making processes and consumer’s attitudes towards food products.

Objective: Students will be able:
- to describe heuristics that influence consumer behavior in the food domain
- to explain the consumer led food product development
- to summarise how consumers perceive the environmental impact and the healthiness of foods
- to assess the cultural, the environmental and the food policy impact on consumer behavior
- to explain psychological factors influencing eating behavior

Public Nutrition and Health

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>752-6101-00L</td>
<td>Nutrition and Chronic Disease</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>F. von Meyenn, M. Andersson</td>
</tr>
</tbody>
</table>
Objective
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Content
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Lecture notes
There is no script. Powerpoint presentations will be made available on-line to students.

Literature
To be provided by the individual lecturers, at their discretion.

Prerequisites / notice
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

752-6105-00L Epidemiology and Prevention
W+ 3 credits 2V M. Puhun, R. Heusser

Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Competencies
- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

444 Safety and Quality in Agri-Food Chain

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<thead>
<tr>
<th>Number</th>
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<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
</tr>
</tbody>
</table>

| Objective
Students will be able...
- to describe heuristics that influence consumer behavior in the food domain
- to explain the consumer led food product development
- to summarise how consumers perceive the environmental impact and the healthiness of foods
- to assess the cultural, the environmental and and the food policy impact on consumer behavior
- to explain psychological factors influencing eating behavior

Competencies
- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

| Number       | Nutritional Aspects of Food Composition and Processing    | W+   | 3    | 2V   | B. E. Baumer, J. M. Sych|

| Abstract
Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.

Objective
Students should be able to
- describe and compare the major concepts /criteria used for the evaluation of the nutritional quality of food
- apply these criteria when assessing the effects of selected processing technologies on nutritional quality.
- evaluate recent formulation strategies aimed to achieve additional physiological benefits for targeted population groups (i.e. functional foods).

Content
The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, separation and emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.

Lecture notes
There is no script. Powerpoint presentations and relevant scientific articles will be available on-line for students. A selection of recommended readings will be given at the beginning of the course.

Prerequisites / notice
The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition, as well as an understanding of food processing.

Competencies
- Subject-specific Competencies
- Method-specific Competencies
- Personal Competencies

| Number       | Forum: Livestock in the World Food System                 | W    | 2    | 2S   | S. Meese               |

| Abstract
This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.

Objective
In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.
The Forum “Livestock in the World Food System” will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

Part 1
- Aspect 1 - Oral presentation: The students form small groups and are lecturers.
- Aspect 2 - chairperson: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
- Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

Part 2.
- Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
- Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Introductions to both presentation forms will be given by the lecturer.

Requirements for allocation of the two credit points:
- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)
- feedback on the presentation style of a student

Competencies

- Subject-specific Competencies
  - Concepts and Theories: fostered
  - Techniques and Technologies: fostered
- Method-specific Competencies
  - Analytical Competencies: fostered
  - Decision-making: fostered
  - Problem-solving: fostered
- Social Competencies
  - Communication: fostered
  - Cooperation and Teamwork: fostered
  - Sensitivity to Diversity: fostered
- Personal Competencies
  - Negotiation: fostered
  - Adaptability and Flexibility: fostered
  - Creative Thinking: fostered
  - Critical Thinking: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

751-7310-00L Bioactive Feed Compounds and Enriched Food Products

Abstract
The course provides students with the basic knowledge to understand the connection between the structure of nutritive and non-nutritive bioactive food and feed components and their effects on the nutrient supply and health of humans and livestock as well as on the quality of animal-derived foods.

Objective
At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

Content
The course gives an introduction into different classes of bioactive components present in food and feed including fatty acids and secondary plant compounds such as carotenoids, polyphenols, phytoestrogens, glucosinolates, protease inhibitors and monoterpenes.

Topics include:
- sources of bioactive food and feed components
- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

751-1301-00L Advanced Topics in Toxicology

Abstract
Journal-club style course involving student presentations and active discussion and critique of recent publications and modern experimental strategies. The focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology, with a new group of topics addressed each semester.

Objective
- to stimulate student interest and provide advanced knowledge of current research in Toxicology and its related sciences
- to develop skills in critical evaluation of scientific literature, oral presentation and questioning
- to understand modern experimental techniques and research approaches relevant in toxicology

Content
The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).

Literature
A selection of approximately 20 papers from recent primary scientific literature.

For Masters level participants, a strict prerequisite is (a) previously taken and passed “Introduction to Toxicology” (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take "Special Topics in Toxicology", do not register at the same time for “Advanced Topics in Toxicology”. It is only possible to take one, and it is only possible to take the advanced level after completing this course.

752-1302-00L Special Topics in Toxicology

Abstract
The course is open to Masters or PhD level students.

Prerequisites / notice
For Masters level participants, a strict prerequisite is (a) previously taken and passed “Introduction to Toxicology” (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1526 of 2667
Recommendations will be given in the first lecture.

M. Puhan

Subject-specific Competencies

Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were fostered. Many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which made and found their way in our daily live. These customized nanomaterials provides extraordinary properties and make them attractive for sustainable use of nanomaterials.

Content

The journal-club style course involves student presentations of recent publications. The primary focus is on chemical and biochemical aspects of selected topics in Toxicology. Participants are generally masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Pharmaceutical Sciences, etc.), and strong knowledge of organic chemistry and biochemistry are prerequisite. Selected course topics change every semester.

Prerequisites / notice

Participants are required to have completed previously "Special Topics in Toxicology" (752-1301-00L). Both courses are run concurrently every semester. It is only possible to register for one course at a time. Do not register for "Advanced Topics in Toxicology" until after you have completed "Special Topics in Toxicology".

752-4009-00L Molecular Biology of Foodborne Pathogens W 3 credits 2V M. Loessner, A. Harms, M. Schuppler, E. Slack

Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Prerequisites / notice

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

Competencies

Subject-specific Competencies

Concepts and Theories - assessed

Techniques and Technologies - assessed

Method-specific Competencies

Analytical Competencies - assessed

Decision-making - fostered

Problem-solving - assessed

Social Competencies

Communication - fostered

Personal Competencies

Creative Thinking - fostered

Critical Thinking - fostered

752-6105-00L Epidemiology and Prevention W 3 credits 2V M. Puhan, R. Heusser

Abstract

The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Competencies

Subject-specific Competencies

Concepts and Theories - assessed

Analytical Competencies - assessed

Decision-making - assessed

Problem-solving - fostered

Project Management - fostered

Social Competencies

Communication - fostered

Cooperation and Teamwork - fostered

Personal Competencies

Creative Thinking - fostered

Critical Thinking - assessed

376-1353-00L Nanostructured Materials Safety W 2 credits 1V P. Wick, T. Bürki-Thurnherr

Abstract

Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.

Objective

Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.

Content

Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily live. These customized nanomaterials provides extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials. The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications and intravenous injections as well as it will provide impulses for safer material designs.

Structure of the planed lecture (2 x 45 min)

1. Introduction: the principles of nanotoxicology
2. Lung- particles interactions: two disease scenarios and their molecular mechanism
3. GI – particles interactions: intendent and unintendent particle exposure via food
4. Skin – particles interactions: body care products and their influence on skin physiology
5. Intravenous injection: colloidal and cellular effects
6. Micro- / Nanoplastics and development of a safety research plan
7. End of semester exam
In Physics of Food Colloids the principles of colloid science will be applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

Notes will be handed out during the lectures.

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<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Critical Thinking</td>
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The aggregation of food material determines the appearance and performance of complex food systems as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

**Objective**
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become capable to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

**Content**
- A motivational application is required:
  - presenting yourself and your studies
  - stating what topic in the field of Political Ecology that you are interested in
  - suggesting one paper to enrich the literature list for the course

Questions regarding the application to johanna.jacobi@usys.ethz.ch.

**Abstract**
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

**Objective**
We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.
Lecture notes

20.9.2024 Introduction to political ecology
27.9.2024 Ontologies and epistemologies
4.10.2024 Green revolution, industrial agriculture, and agroecology
11.10.2024 Don't blame the rain: Water management in agriculture
18.10.2024 Climate justice and food systems
25.10.2024 Conservation: Protecting what from what?
1.11.2024 Deforestation: Root causes and alternatives
8.11.2024 Pandemics, syndemics and the food system
15.11.2024 Technology and the politics of knowledge
22.1.2024 Land-sharing, land-sparing
29.11.2024 Feminist (political) agroecology
6.12.2024 Food: Commons or commodity?
13.12.2024 Alternatives to sustainable development
20.12.2024 Final session (The Hunger Banquet)

Literature
Literature list provided on Moodle when the course starts.

https://moodle-app2.let.ethz.ch/course/view.php?id=20544

Competencies

Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered

Social Competencies
Cooperation and Teamwork fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity assessed
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Negotiation fostered

Master's Thesis

Number Title Type ECTS Hours Lecturers
752-0230-00L Master's Thesis O 30 credits 64D Supervisors

Abstract
The Master thesis completes the master programme and is an independent scientific project. Generally, the topic is selected from the specific field of the major. It is supervised by a professor/Privatdozents at D-HEST or D-USYS, Agricultural Sciences.

Objective
The Master Thesis must demonstrate the student's ability to independent, structured and scientific working.

Master Studies (Programme Regulations 2024)

Major in Food Science and Technology

Minor Human Nutrition

The minor Human Nutrition can only be chosen in connection with the major in Food Science and Technology.

Number Title Type ECTS Hours Lecturers
401-0625-01L Applied Analysis of Variance and Experimental Design W 5 credits 2V+1U L. Meier

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorial and fractional designs, power.

Literature

Nutrition and Chronic Disease

Number Title Type ECTS Hours Lecturers
752-6101-00L Nutrition and Chronic Disease W 3 credits 2V F. von Meyenn, M. Andersson

Abstract
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.
**Analytical Competencies**

Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

**Method-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management
- Cooperation and Teamwork
- Critical Thinking

**Social Competencies**

- Communication
- Sensitivity to Diversity
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

**Epidemiology and Prevention**

**Abstract**

The module Epidemiology and Prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

**Objective**

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

**Content**

The module Epidemiology and Prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

**Competencies**

- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

**Food Enzymology**

The course covers the fundamentals of food enzymology, application of endogenous and exogenous enzymes in food processing, as well as use of enzymes in analytics.

**Objective**

Students can describe what enzymes are and can explain their use and functions in food and food products. Students can argue why and how enzymes are used in food processing and analysis.

**Content**

Enzymes in foods: the use of added enzymes in food processing, control and/or utilization of endogenous enzymes, production of enzyme preparations for food use, and chemical analysis of food components by enzymatic methods.

**Competencies**

- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

**Physics of Food Colloids**

Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

**Method-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Creative Thinking

**Personal Competencies**

- Critical Thinking

**Literature**

- Provided in the lecture notes.

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**Core courses FST**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-1021-00L</td>
<td>Food Enzymology</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>L. Nyström, M. Erzinger</td>
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<tr>
<td>752-3103-00L</td>
<td>Food Rheology</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>P. A. Fischer</td>
</tr>
<tr>
<td>752-2314-00L</td>
<td>Physics of Food Colloids</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>P. A. Fischer, R. Mezzenga,</td>
</tr>
</tbody>
</table>
Abstract
In Physics of Food Colloids the principles of colloid science will be applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

Objective
The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Content
Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge of common food products.

Lecture notes
Notes will be handed out during the lectures.

Literature
Provided in the lecture notes.

Competencies

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<tr>
<td>W+</td>
<td>3 credits</td>
<td>M. Loessner, A. Harms, M. Schuppler, E. Slack</td>
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752-4009-00L Molecular Biology of Foodborne Pathogens

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

Competencies

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<tr>
<td>W+</td>
<td>3 credits</td>
<td>F. von Meyenn, M. Andersson</td>
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752-6101-00L Nutrition and Chronic Disease

Abstract
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Objective
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Content
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Lecture notes
There is no script. Powerpoint presentations will be made available on-line to students.

Literature
To be provided by the individual lecturers, at their discretion.

Prerequisites / notice
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

752-6105-00L Epidemiology and Prevention

Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.
The journal-club style course involves student presentations of recent publications. The primary focus is on chemical and biochemical aspects of selected current topics in Toxicology. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the seminar presentations.

The objectives are to become familiar with and stimulate interest in leading-edge science related to the research topics of the Institute of Food, Nutrition and Health. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the seminar presentations.

The course is open to Masters or PhD level students.

For Masters level participants, a strict prerequisite is (a) previously taken and passed "Introduction to Toxicology" (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

The student should develop skills in the critical evaluation of scientific literature, oral presentation and questioning, and understanding modern experimental techniques in Toxicology.

The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology, with a new group of topics addressed each semester.

The course is open to Masters or PhD level students.

Only for students who have previously taken "Special Topics in Food Toxicology" (752-1301-00L). Both courses are run concurrently every semester. It is only possible to register for one course at a time. Do not register for "Advanced Topics in Toxicology" until after you have completed "Special Topics in Toxicology".
### 752-2003-00L
**Selected Topics in Food Technology**

**W+** 3 credits  2V  R. Stadler, C. Bolten

**Abstract**
Part 1 of the course deals with global market trends, food technologies, food health benefits. Physical and chemical fundamental knowledge help grasp the molecular composition of food. Part 2 entails management of risks across the food supply chain. The focus is on technological solutions to mitigate hazards, as well as their management upstream.

**Objective**
The objectives of the course are for students to understand the key drivers (market and consumer trends, health benefits, sustainability, etc.) that impact innovation in a food business environment. The course also illustrates food safety and quality considerations across the whole supply chain, using concrete examples and how certain technologies assist in reducing or eliminating food safety risks.

**Competencies**

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### 752-2122-00L
**Food and Consumer Behaviour**

**W+** 2 credits  2V  M. Siegrist, F. Michel

**Abstract**
This course focuses on food consumer behavior, consumer’s decision-making processes and consumer’s attitudes towards food products.

**Objective**
Students will be able to:
- to describe heuristics that influence consumer behavior in the food domain
- to explain the consumer led food product development
- to summarise how consumers perceive the environmental impact and the healthiness of foods
- to assess the cultural, the environmental and the food policy impact on consumer behavior
- to explain psychological factors influencing eating behavior

**Competencies**

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### 752-2307-00L
**Nutritional Aspects of Food Composition and Processing**

**W+** 3 credits  2V  B. E. Baumer, J. M. Sych

**Abstract**
Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.

**Objective**
Students should be able to:
- describe and compare the major concepts/criteria used for the evaluation of the nutritional quality of food
- apply these criteria when assessing the effects of selected processing technologies on nutritional quality.
- evaluate recent formulation strategies aimed to achieve additional physiological benefits for targeted population groups (i.e. functional foods).

**Content**
The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, separation and emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.

**Lecture notes**
There is no script. Powerpoint presentations and relevant scientific articles will be available on-line for students. A selection of recommended readings will be given at the beginning of the course.

**Prerequisites / notice**
The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

**Competencies**

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### 752-3105-00L
**Physiology Guided Food Structure and Process Design**

**W+** 3 credits  2V  P. A. Fischer, M. Devezeaux de Lavergne, B. von der Weid, T. Wooster

**Abstract**
A sound understanding of physiological implications of food design will allow to shape new products, which feature health as well as environmental benefits and on the other side do not compromise on organoleptic qualities, formulation and manufacturing, and quality and safety. The course links the physiological driven requirements with food structure design and subsequent engineering steps.

**Objective**
The objective of this course is to highlight the link between human physiology, product sensory, nutritional functions, and engineering approaches to facilitate the design of food matrices reflecting the requirements for the beforementioned properties. To identify and manipulate these properties, the pathways that control the interaction of food structures and their physiological action will be introduced. Students are introduced to a skill set that will encompass basic digestion, sensory physiology knowledge, and food structures. Students will be exposed to the interplay along the gastrointestinal tract including taste, aroma, and texture perception, swallowing mechanics, and gastrointestinal digestion with an engineering or physical sciences angle.

**Content**
Chapter 1: Introduction - The need for physiology guided structure and process design in the context of personalized nutrition (Peter Fischer)
Chapter 2: Food Oral Processing: the impact of food oral breakdown on sensory perception (Marine Devezeaux de Lavergne)
Chapter 3: Chewing and swallowing across the lifespan, from infants to elderly (Marine Devezeaux de Lavergne)
Chapter 4: Perception physiology in humans and other species (Benot von der Weid)
Chapter 5: Biophysics of food digestion & how it can be exploited in the development of strategies for delivery (Timothy J. Wooster)
Chapter 6: Numerical and experimental modelling of the intestinal system (Peter Fischer)

**Lecture notes**
Lecture notes are available at Moodle

**Competencies**

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<td>Integrity and Work Ethics</td>
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### 752-3201-00L
**Emerging Thermal and Non Thermal Food Processing**

**W+** 3 credits  2V  A. Mathys, J. Dumpler
**Abstract**

This course is built on the holistic approach in sustainable food processing via the consideration of the total value chain. Selected mechanical, biotechnological, thermal and non-thermal techniques for best biomass and energy use efficiency will be investigated. Focused technologies are new thermal processes, high pressure techniques, electroporation and different radiation based sources.

**Objective**

Understanding of selected emerging food processing concepts with focus on lower process intensity for healthy and high quality food production, waste reduction as well as biomass and energy use efficiency. Updates from academia and industry around new trends in food process development.

**Content**

Emerging combined processes based on mechanical, thermal and non-thermal techniques, Multi hurdle technology concept for preservation, Extreme high temperature-short time processes, high pressure techniques, electroporation, radiation, Biorefineries based on emerging process elements, Ongoing industry initiatives

**Lecture notes**

Script will be distributed before the course via Moodle.

**Literature**


Robert D. Axelrod, Julia Baumgartner, Michael Beyer and Alexander Mathys. Experimental and simulation-based investigation of the interplay between factor gradients following pulsed electric field treatments triggering whey protein aggregation. Journal of Food Engineering, vol. 340, pp. 111308

**752-5105-00L Biotechnology of Alcoholic Beverage Production**

- **W+ 2 credits 2V**

- **R. Mira de Ondrea Heidinger**, N. Bokulich, M. Rienth

**Abstract**

This course introduces fundamental aspects of the production of beer and grape wine.

**Objective**

The objective of the course is to provide participating students with a sound understanding of the raw materials, microorganisms, microbial and chemical transformations and processing aspects involved in the production of beer and grape wine. Sensory aspects and product stability will also be considered.

**Content**

- **Introduction of alcoholic beverage production within industrial microbiology**
  - **Brewing**
  - Raw materials, and malting
  - Brewhouse processes, wort production, fermentations, lagering
  - Sensory aspects and diacetyl management
  - **Winemaking**
  - Grapegrowing and grape processing
  - Crush and pressing
  - Fermentations and microbial transformations
  - Fining, stabilizations, filtration and bottling
  - Aroma and macromolecule chemistry, climate change
  - Sensory aspects and wine faults

**Lecture notes**

Lecture handouts will be provided electronically. The lectures will not be recorded.

**Literature**

A list of learning materials will be provided online.

**Prerequisites / notice**

Students taking 752-5105-00L require a sound knowledge of basic chemistry, biochemistry, molecular genetics, microbiology and microbial physiology.

In order to decipher the costs of tastings, a financial participation of CHF25 will be required per student.
The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice
No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

Students will bring and work on their own laptop computers.

All software used in the course is free and open-source.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Social Competencies
Communication
Cooperation and Teamwork
Personal Competencies
Creative Thinking
Critical Thinking
Self-direction and Self-management

752-6151-00L Public Health Concepts W+ 3 credits 2V R. Heusser

Abstract
The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

Objective
At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

Content
Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition).

Lecture notes
Handouts are provided to students in the classroom.

752-6403-00L Nutrition and Performance W+ 2 credits 2V S. Mettler

Abstract
The course introduces basic concepts of the interaction between nutrition and exercise performance.

Objective
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

Content
The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

Lecture notes
Lecture slides and required handouts will be available on the ETH website (moodle).

752-6301-00L Nutrition-Related Physiology W+ 3 credits 2V F. von Meyenn, E. Gasser

Abstract
Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and their functioning, as well as the malfunctioning, of major organ systems on the other hand.
The minor Food Processing can only be chosen in connection with the major in Nutrition and Health.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
752-3105-00L | Physiology Guided Food Structure and Process | W | 3 credits | 2V | P. A. Fischer.
A sound understanding of physiological implications of food design will allow to shape new products, which feature health as well as environmental benefits and on the other side do not compromise on organoleptic qualities, formulation and manufacturing, and quality and safety. The course links the physiological driven requirements with food structure design and subsequent engineering steps.

The objective of this course is to highlight the link between human physiology, product sensory, nutritional functions, and engineering approaches to facilitate the design of food matrices reflecting the requirements for the beforementioned properties. To identify and manipulate these properties, the pathways that control the interaction of food structures and their physiological action will be introduced. Students are introduced to a skill set that will encompass basic digestion, sensory physiology knowledge, and food structures. Students will be exposed to the interplay along the gastrointestinal tract including taste, aroma, and texture perception, swelling mechanisms, and gastrointestinal digestion with an engineering or physical sciences angle.

Chapter 1: Introduction - The need for physiology guided structure and process design in the context of personalized nutrition (Peter Fischer)

Chapter 2: Food Oral Processing: the impact of food oral breakdown on sensory perception (Marine Devezeaux de Lavergne)

Chapter 3: Chewing and swallowing across the lifespan, from infants to elderly (Marine Devezeaux de Lavergne)

Chapter 4: Perception physiology in humans and other species (Benot von der Weid)

Chapter 5: Biophysics of food digestion & how it can be exploited in the development of strategies for delivery (Timothy J. Wooster)

Chapter 6: Numerical and experimental modelling of the intestinal system (Peter Fischer)
The course covers the fundamentals of food enzymology, application of endogenous and exogenous enzymes in food processing, as well as use of enzymes in analytics.

**Objective**

Students can describe what enzymes are and can explain their use and functions in food and food products. Students can argue why and how enzymes are used in food processing and analysis. Students execute a research project independently and defend their findings during a presentation to peer students and an expert panel.

**Content**

Enzymes in foods; the use of added enzymes in food processing, control and/or utilization of endogenous enzymes, production of enzyme preparations for food use, and chemical analysis of food components by enzymatic methods. Course contains lectures and a practical group work.

**Lecture notes**

The lectures are supplemented with handouts.

**Prerequisites / notice**

Course prerequisites: Food Chemistry I/II and Food Analysis I/II (or equivalent)
Subject-specific Competencies

Provided in the lecture notes.

Method-specific Competencies

Copies of the presentations will be handed out or the presentations are made available via moodle.

Social Competencies

Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

Personal Competencies

Notes will be handed out during the lectures.

752-3103-00L Food Rheology

Abstract

Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

Objective

The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

Content

Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

Lecture notes

Notes will be handed out during the lectures.

Literature

Provided in the lecture notes.

Competencies

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752-2314-00L Physics of Food Colloids

Abstract

In Physics of Food Colloids the principles of colloid science will applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

Objective

The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Content

Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

Lecture notes

Notes will be handed out during the lectures.

Literature

Provided in the lecture notes.

Competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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752-0005-00L Colloquium in Food and Nutrition Science

Abstract

Participation in weekly seminars on a variety of topics including Food Microbiology, Food Toxicology, Food Biochemistry, Food Processing, Consumer Behavior, Food Technology, and Food Materials and Technology, and oral presentation of a selected published study in one of these areas inspired by participation in the seminars.

Objective

The objectives are to become familiar and with stimulate interest in leading-edge science related to the research topics of the Institute of Food, Nutrition and Health. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the semester presentations.

752-0801-00L Food Law and Legislation

Abstract

Introduction to the principles of the EU and international organisations. Set up and Application of the Swiss Food Law.

Objective

Knowledge of the principles and the structure of the EU in general and in the area of food safety, overview of the relevant bilateral agreements CH-EU as well as on the most important international organisations.

Basic knowledge of the structure of Swiss food law and its implementation in the context of self-controll in food companies. The process of food enforcement is known and issues can be assessed from a legal perspective.

Content

General introduction into the EU and in the area of food safety (regulation on food safety), legislative procedures in the EU, introduction into the relevant bilateral agreements CH-EU, introduction into international organisations, general principles of the Swiss food law and the most important regulations as well as the most important legal procedures, legal settlement and the duties and responsibilities of the Food control authorities.

Lecture notes

Copies of the presentations will be handed out or the presentations are made available via moodle.

Literature

Documents about the EU regulation on Food Safety will be handed out. Swiss law is available online via the systematic collection of laws.

Prerequisites / notice

Qualifications: General knowledge of the food sciences.

The lecture will be held in German.
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### 752-1301-00L Special Topics in Toxicology

**Objective**
- to stimulate student interest and provide advanced knowledge of current research in Toxicology and its related sciences
- to develop skills in critical evaluation of scientific literature, oral presentation and questioning
- to understand modern experimental techniques and research approaches relevant in Toxicology

**Content**
The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).

**Literature**
A selection of approximately 20 papers from recent primary scientific literature.

**Prerequisites / notice**
The course is open to Masters or PhD level students.

For Masters level participants, a strict prerequisite is (a) previously taken and passed "Introduction to Toxicology" (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take "Special Topics in Toxicology", do not register at the same time for "Advanced Topics in Toxicology". It is only possible to take one, and it is only possible to take the advanced level after completing this course.

### 752-1302-00L Advanced Topics in Toxicology

**Objective**
The goals are to stimulate student interest and provide advanced knowledge of current research in the interdisciplinary area of Food and Nutrition Toxicology and its related sciences. The student should develop skills in the critical evaluation of scientific literature, oral presentation and questioning, and understanding modern experimental techniques in Molecular Toxicology.

**Content**
The journal-club style course involves student presentations of recent publications. The primary focus is on chemical and biochemical aspects of selected topics in Toxicology. Participants are generally masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Pharmaceutical Sciences, etc.), and strong knowledge of organic chemistry and biochemistry are prerequisite. Selected course topics change every semester.

**Prerequisites / notice**
Participants are required to have completed previously "Special Topics in Toxicology" (752-1301-00L). Both courses are run concurrently every semester. It is only possible to register for one course at a time. Do not register for "Advanced Topics in Toxicology" until after you have completed "Special Topics in Toxicology".

### 752-2003-00L Selected Topics in Food Technology

**Objective**
The objectives of the course are for students to understand the key drivers (market and consumer trends, health benefits, sustainability, etc.) that impact innovation in a food business environment. The course also illustrates food safety and quality considerations across the whole supply chain, using concrete examples and how certain technologies assist in reducing or eliminating food safety risks.

**Content**
Part 1 of the course deals with global market trends, food technologies, food health benefits. Physical and chemical fundamental knowledge help grasp the molecular composition of food. Part 2 entails management of risks across the food supply chain. The focus is on technological solutions to mitigate hazards, as well as their management upstream.

**Prerequisites / notice**
Participants are required to have completed previously "Special Topics in Toxicology" (752-1301-00L). Only for students who have previously taken "Special Topics in Food Toxicology" (752-1301-00L).

### 752-2122-00L Food and Consumer Behaviour

**Objective**
This course focuses on food consumer behavior, consumer’s decision-making processes and consumer's attitudes towards food products. Students will be able...
- to describe heuristics that influence consumer behavior in the food domain
- to explain the consumer led food product development
- to summarise how consumers perceive the environmental impact and the healthiness of foods
- to assess the cultural, the environmental and the food policy impact on consumer behavior
- to explain psychological factors influencing eating behavior

**Competencies**

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### 752-2307-00L Nutritional Aspects of Food Composition and Processing

**Objective**
Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.
Objective: Students should be able to describe and compare the major concepts/criteria used for the evaluation of the nutritional quality of food - apply these criteria when assessing the effects of selected processing technologies on nutritional quality. Evaluate recent formulation strategies aimed at achieving additional physiological benefits for targeted population groups (i.e., functional foods).

Content: The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, separation, and emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g., nutritional profiles) and how these are communicated to consumers are also discussed.

Lecture notes: There is no script. PowerPoint presentations and relevant scientific articles will be available online for students. A selection of recommended readings will be given at the beginning of the course.

Prerequisites: The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.


Course: 752-3105-00L Physiology Guided Food Structure and Process Design

W+ 3 credits 2V 752-3105-00L P. A. Fischer, M. Devezeaux de Lavergne, B. von der Weid, T. Wooster

Abstract: A sound understanding of physiological implications of food design will allow to shape new products, which feature health as well as environmental benefits and on the other side do not compromise on organoleptic qualities, formulation, and manufacturing, and quality and safety. The course links the physiological driven requirements with food structure design and subsequent engineering steps.

Objective: The objective of this course is to highlight the link between human physiology, product sensory, nutritional functions, and engineering approaches to facilitate the design of food matrixes reflecting the requirements for the beforementioned properties. To identify and manipulate these properties, the pathways that control the interaction of food structures and their physiological action will be introduced. Students are introduced to a skill set that will encompass basic digestion, sensory physiology knowledge, and food structures. Students will be exposed to the interplay along the gastrointestinal tract including taste, aroma, and texture perception, swallowing mechanics, and gastrointestinal digestion with an engineering or physical sciences angle.

Content: Chapter 1: Introduction - The need for physiology guided structure and process design in the context of personalized nutrition (Peter Fischer)
Chapter 2: Food Oral Processing: the impact of food oral breakdown on sensory perception (Marine Devezeaux de Lavergne)
Chapter 3: Chewing and swallowing across the lifespan, from infants to elderly (Marine Devezeaux de Lavergne)
Chapter 4: Perception physiology in humans and other species (Benoit von der Weid)
Chapter 5: Biophysics of food digestion & how it can be exploited in the development of strategies for delivery (Timothy J. Wooster)
Chapter 6: Numerical and experimental modelling of the intestinal system (Peter Fischer)

Lecture notes: Lecture notes are available at Moodle.

Competencies: Subject-specific Competencies - Concepts and Theories assessed, Techniques and Technologies assessed.
Method-specific Competencies - Analytical Competencies fostered, Decision-making fostered, Media and Digital Technologies fostered, Problem-solving fostered, Project Management fostered, Communication fostered, Creative Thinking fostered, Critical Thinking fostered, Integrity and Work Ethics fostered.

Course: 752-3201-00L Emerging Thermal and Non Thermal Food Processing

W+ 3 credits 2V 752-3201-00L A. Mathys, J. Dumpler

Abstract: This course is built on the holistic approach in sustainable food processing via the consideration of the total value chain. Selected mechanical, biotechnological, thermal and non-thermal techniques for best biomass and energy use efficiency will be investigated. Focused technologies are new thermal processes, high pressure techniques, electroporation, and different radiation-based sources.

Objective: Understanding of selected emerging food processing concepts with focus on lower process intensity for healthy and high-quality food production, waste reduction as well as biomass and energy use efficiency. Updates from academia and industry around new trends in food process development.


Lecture notes: Script will be distributed before the course via Moodle.
Introduction of alcoholic beverage production within industrial microbiology

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies

Communication assessed

Personal Competencies

Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management assessed

Abstract

This course introduces fundamental aspects of the production of beer and grape wine.

Objective

The objective of the course is to provide participating students with a sound understanding of the raw materials, microorganisms, microbial and chemical transformations and processing aspects involved in the production of beer and grape wine. Sensory aspects and product stability will also be considered.

Content

>> Introduction of alcoholic beverage production within industrial microbiology

>> Brewing
- Raw materials, and malting
- Brewhouse processes, wort production, fermentations, lagering
- Sensory aspects and diacetyl management

>> Winemaking
- Grape growing and grape processing
- Crush and pressing
- Fermentations and microbial transformations
- Fining, stabilizations, filtration and bottling
- Aroma and macromolecule chemistry, climate change
- Sensory aspects and wine faults

Lecture notes

Lecture handouts will be provided electronically. The lectures will not be recorded.

Literature

A list of learning materials will be provided online.

Prerequisites / notice

Students taking 752-5105-00L require a sound knowledge of basic chemistry, biochemistry, molecular genetics, microbiology and microbial physiology.

In order to decipher the costs of tastings, a financial participation of CHF25 will be required per student.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Social Competencies

Communication assessed

Personal Competencies

Critical Thinking assessed
Objectives:
Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

Content:
1. Introduction to microbiomes and microbial bioinformatics toolkit. Python, Pandas, Jupyter, GitHub, visualization libraries for Python.
3. Microbial diversity, function, and ecology. Molecular ecology, diversity metrics, ordination methods.
4. Advanced topics in microbial bioinformatics. Metagenomics, machine learning, functional analysis, data visualization, etc.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice:
No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

All software used in the course is free and open-source.

Competencies:
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Social Competencies: Communication, Cooperation and Teamwork
- Personal Competencies: Creative Thinking, Critical Thinking, Self-direction and Self-management

752-6151-00L Public Health Concepts

Abstract:
The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

Objective:
At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

Content:
Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, iodine/PK nutrition).

Lecture notes:
Handouts are provided to students in the classroom.

752-6151-00L Competencies

- Subject-specific Competencies: assessed
- Method-specific Competencies: assessed
- Social Competencies: fostered
- Personal Competencies: fostered

752-6403-00L Nutrition and Performance

Abstract:
The course introduces basic concepts of the interaction between nutrition and exercise performance.

Objective:
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during, and after exercise.

Content:
The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

Lecture notes:
Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

752-6403-00L Prerequisites / notice

- General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

752-6301-00L Nutrition-Related Physiology

Abstract:
Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand. For students with a background in medicine, pharmacy or biology, the course is useful as a review of previously acquired knowledge. Major topics are basic neuroanatomy and neurophysiology; general endocrinology; the physiology of taste and smell; nutrient digestion and absorption; intermediary metabolism and energy homeostasis; and some aspects of cardiovascular physiology and water balance.

Objective:
Some basic knowledge in physiology is recommended for this course, which revisits important physiological topics, emphasizing their relation to nutrition. The aim is to give the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand.

Lecture notes:
Handouts for each lecture will be uploaded to Moodle every week.

752-6301-00L Competencies

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Problem-solving
- Personal Competencies: Critical Thinking
### Minors

#### Statistical Methods in Food Science and Nutrition

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<th>Number</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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</tbody>
</table>

Abstract

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes

A script will be available.
Prerequisites / notice

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Literature

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

401-0625-01L Applied Analysis of Variance and Experimental Design

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

752-5500-00L Applied Bioinformatics: Microbiomes

Abstract
Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

Objective
Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

Content
1. Introduction to microbiomes and microbial bioinformatics toolkit. Python, Pandas, Jupyter, GitHub, visualization libraries for Python.
3. Microbial diversity, function, and ecology. Molecular ecology, diversity metrics, ordination methods.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice
No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

Students will bring and work on their own laptop computers.

All software used in the course is free and open-source.
This course covers the main methods used in Biostatistics. It starts by revising Linear Models (Regression, Anova), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

After this course students:
- revised Linear Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions

This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both, part one and two will include the following topics: exploratory data analysis, model fitting, model "selection", residual diagnostics, model validation and results interpretation. Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analysing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommend to view the online R course "etutoR".

### Consumer and Sensory Science

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<tr>
<td>752-5105-00L</td>
<td>Biotechnology of Alcoholic Beverage Production</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>R. Mira de Orduna Heidinger, N. Bokulich, M. Rienth</td>
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- **Abstract**: This course introduces fundamental aspects of the production of beer and grape wine.
- **Objective**: The objective of the course is to provide participating students with a sound understanding of the raw materials, microorganisms, microbial and chemical transformations and processing aspects involved in the production of beer and grape wine. Sensory aspects and product stability will also be considered.
- **Content**: >> Introduction of alcoholic beverage production within industrial microbiology
  - Raw materials, and malting
  - Brewhouse processes, wort production, fermentations, lagering
  - Sensory aspects and diacetyl management
- Winemaking
  - Grape growing and grape processing
  - Crush and pressing
  - Fermentations and microbial transformations
  - Fining, stabilizations, filtration and bottling
  - Aroma and macromolecule chemistry, climate change
  - Sensory aspects and wine faults

- **Prerequisites / notice**: Students taking 752-5105-00L require a sound knowledge of basic chemistry, biochemistry, molecular genetics, microbiology and microbial physiology.

In order to decipher the costs of tastings, a financial participation of CHF25 will be required per student.

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### Applied Analysis of Variance and Experimental Design

- **Abstract**: Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.
- **Objective**: Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.
- **Content**: Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.
- **Prerequisites / notice**: The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

- **Biotechnology of Alcoholic Beverage Production**
  - **Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.**

- **Applied Analysis of Variance and Experimental Design**
  - **Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.**

- **Introduction of alcoholic beverage production within industrial microbiology**
  - **Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.**

- **Brewing and chemical transformations and processing aspects involved in the production of beer and grape wine. Sensory aspects and product stability will also be considered.**
  - ** consumer chemical, biochemical, and nutritional aspects of selected current topics in Toxicology, with a new group of topics addressed each semester.**

- **Sensory aspects and wine faults**
  - **Sensory aspects and diacetyl management**

- **Food Safety**
  - **Food Safety**
  - **Food Safety**
**Abstract**
Journal-club style course that involves student presentations of selected topics in Toxicology on the basis of current primary research and review papers.

**Objective**
The goals are to stimulate student interest and provide advanced knowledge of current research in the interdisciplinary area of Food and Nutrition Toxicology and its related sciences. The student should develop skills in the critical evaluation of scientific literature, oral presentation and questioning, and understanding modern experimental techniques in Molecular Toxicology.

**Content**
The journal-club style course involves student presentations of recent publications. The primary focus is on chemical and biochemical aspects of selected topics in Toxicology. Participants are generally masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Pharmaceutical Sciences, etc.), and strong knowledge of organic chemistry and biochemistry are prerequisite. Selected course topics change every semester.

**Prerequisites / notice**
Participants are required to have completed previously "Special Topics in Toxicology" (752-1301-00L). Both courses are run concurrently every semester. It is only possible to register for one course at a time. Do not register for "Advanced Topics in Toxicology" until after you have completed "Special Topics in Toxicology".

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**Nanostructured Materials Safety**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-1353-00L</td>
<td>Nanostructured Materials Safety</td>
<td>2 credits</td>
<td>1V</td>
<td>P. Wick, T. Bürki-Thurnherr</td>
<td></td>
</tr>
</tbody>
</table>

**Abstract**
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.

**Objective**
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.

**Content**
Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily live. These customized nanomaterials provides extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials.

The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications and intravenous injections as well as it will provide impulses for safer material designs.

**Structure of the planed lecture (2 x 45 min)**
1. Introduction: the principles of nanotoxicology
2. Lung - particles interactions: two disease scenarios and their molecular mechanism
3. GI – particles interactions: intendent and unintendent particle exposure via food
4. Skin – particles interactions: body care products and their influence on skin physiology
5. Intravenous injection: colloidal stability, protein corona and cellular effects
6. Micro-/Nanoplastics and development of a safety research plan
7. End of semester exam

**Lecture notes**
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

**Prerequisites / notice**
course "Introduction to Toxicology"

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**Electives**

**Minor Human Nutrition**

**Minor Food Processing**

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**Colloquium in Food and Nutrition Science**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>752-0005-00L</td>
<td>Colloquium in Food and Nutrition Science</td>
<td>1 credit</td>
<td>2K</td>
<td>S. J. Sturla</td>
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</tbody>
</table>

**Abstract**
Participation in weekly seminars on a variety of topics including Food Microbiology, Food Toxicology, Food Biochemistry, Food Processing, Consumer Behavior, Food Technology, and Food Materials and Technology, and oral presentation of a selected published study in one of these areas participated in the seminars.

**Objective**
The objectives are to become familiar with and stimulate interest in leading-edge science related to the research topics of the Institute of Food, Nutrition and Health. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the semester presentations.

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**Political Ecology of Food and Agriculture**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>751-2105-00L</td>
<td>Political Ecology of Food and Agriculture</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Jacobi</td>
<td></td>
</tr>
</tbody>
</table>

**Abstract**
Number of participants limited to 25
A motivational application is required:
- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Questions regarding the application to
johanna.jacobi@usi.ethz.ch.

**Objective**
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods
Content

We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

Lecture notes

20.9.2024 Introduction to political ecology
27.9.2024 Ontologies and epistemologies
4.10.2024 Green revolution, industrial agriculture, and agroecology
11.10.2024 Don't blame the rain: Water management in agriculture
18.10.2024 Climate justice and food systems
25.10.2024 Conservation: Protecting what from what?
1.11.2024 Deforestation: Root causes and alternatives
8.11.2024 Pandemics, syndemics and the food system
15.11.2024 Technology and the politics of knowledge
22.11.2024 Land-sharing, land-sparing
29.11.2024 Feminist (political) agroecology
6.12.2024 Food: Commons or commodity?
13.12.2024 Alternatives to sustainable development
20.12.2024 Final session (The Hunger Banquet)

Literature

https://moodle-app2.let.ethz.ch/course/view.php?id=20544

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>fostered</td>
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<td></td>
<td>Decision-making</td>
<td>fostered</td>
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<td></td>
<td>Problem-solving</td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>fostered</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Negotiation</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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</tbody>
</table>

Science in Perspective

Recommended Science in Perspective (Type B) for D-HEST

see Science in Perspective: Type A: Enhancement of Reflection Capability

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis

Number Title Type ECTS Hours Lecturers
752-0231-00L Master's Thesis O 30 credits 64D Supervisors

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

Number Title Type ECTS Hours Lecturers
752-1000-AAL Food Chemistry I E- 3 credits 6R L. Nyström

Abstract

To familiarise with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.

Objective

To familiarise with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.

Content

Descriptive chemistry of food constituents (proteins, lipids, carbohydrates, plant phenolics, flavour compounds).

Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (e.g. lipid oxidation, Maillard reaction, enzymatic browning).

Links to food analysis, food processing, and nutrition.

Lecture notes

The lectures are supplemented with handouts.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecturer(s)</th>
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<tr>
<td>752-1101-AAL</td>
<td>General Biology I</td>
<td>6</td>
<td>L. Nyström</td>
</tr>
<tr>
<td>752-3000-AAL</td>
<td>Food Process Engineering I</td>
<td>4</td>
<td>P. A. Fischer</td>
</tr>
<tr>
<td>752-6001-AAL</td>
<td>Introduction to Nutritional Science</td>
<td>3</td>
<td>F. von Meyenn</td>
</tr>
<tr>
<td>551-0001-AAL</td>
<td>Food Analysis I</td>
<td>3</td>
<td>U. Sauer, O. Y. Martin, A. Widmer</td>
</tr>
</tbody>
</table>

**Food Analysis I**

**Enrolment Only for MSc students with a decree declaring this course unit as an additional admission requirement.**

**Abstract**

To understand the basic principles of analytical chemistry. To get acquainted with the principles and applications of important routine methods of instrumental food analysis (UV/VIS, IR, AAS, GC, HPLC).

**Objective**

To understand the basic principles of analytical chemistry. To get acquainted with the principles and applications of important routine methods of instrumental food analysis (UV/VIS, IR, AAS, GC, HPLC).

**Content**

Methods: Chemical concentrations. The analytical process (sampling, sample preparation, calibration, measurement, statistical evaluation of analytical results). Errors in quantitative analysis. Important parameters of an analytical procedure (accuracy, precision, limit of detection, sensitivity, specificity/selectivity).

**Lecture Notes**

The lectures are supplemented with handouts.

**Literature**


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**Food Process Engineering I**

**Enrolment Only for MSc students with a decree declaring this course unit as an additional admission requirement.**

**Abstract**

To procure students with the basic physics of food process engineering, especially with the mechanical futures of food systems, i.e. basic principles of engineering mechanics, of thermodynamics, fluid dynamics and of dimension analyses for process design and Non-Newtonian fluid mechanics.

**Objective**


**Content**


**Lecture Notes**

The lectures are supplemented with handouts.

**Literature**

P. Grassmann: Einführung in die thermische Verfahrenstechnik, de Gruyter Berlin, 1997


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**Introduction to Nutritional Science**

**Enrolment Only for MSc students with a decree declaring this course unit as an additional admission requirement.**

**Abstract**

This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

**Objective**

To introduce the students to the both macro- and micronutrients in relation to food and metabolism.

**Content**

This is a self-study course. The course is divided into two parts: micronutrients and macronutrients. The micronutrients include fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. The part on macronutrients introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism.

**Lecture Notes**

A reading list will be provided to the students detailing chapters and lecture slides to be studied.

**Literature**


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**General Biology I**

**Enrolment Only for MSc students with a decree declaring this course unit as an additional admission requirement.**

**Abstract**

Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

**Objective**

The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.
Content
The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogenic reconstructions
23 Evolution Microevolution
24 Evolution Species and specialization
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
28 Diversity of Life Origin & evolution of eukaryotes
29 Diversity of Life Nonvascular & seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

Lecture notes
No script

Literature

Prerequisites / notice
This is a virtual self-study lecture for non-german speakers of the "Allgemeine Biology I (551-0001-00L) lecture. The exam will be written jointly with the participants of this lecture.

Example exam questions will be discussed during the lectures, and old exam questions are kept by the various student organisations. If necessary, please contact Prof. Uwe Sauer (sauer@ethz.ch) for details regarding the exam.

406-0063-AAL
Physics II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the "way of thinking" and the methodology in Physics. The Chapters treated are Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter. The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

Content
Book:

Chapters:

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003
4th edition 2022

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered
Method-specific Competencies
Analytical Competencies fostered
Problem-solving assessed
Personal Competencies
Self-direction and Self-management fostered

406-0603-AAL
Stochastics (Probability and Statistics)
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".
Content

From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature

- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m1757b/

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed

Personal Competencies

Self-direction and Self-management assessed

752-4001-AAL Microbiology E- 2 credits 4R M. Schuppler
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Self-study course in microbiology.

Objective

Teaching of basic knowledge in microbiology.

Content

This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology.

Literature

This self-study course is based on the book ‘Brock, Biology of Microorganisms’.

701-0071-AAL Mathematics III: Systems Analysis E- 4 credits 9R R. Knutti, H. Wernli
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective

Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content

Introduction to principles of models; one-dimensional linear box models; multi-dimensional linear box models; nonlinear box models; models in space and time.

Lecture notes

Teaching material: book (see literature).

Literature


752-4005-AAL Food Microbiology I E- 3 credits 6R M. Loessner
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Objective

The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

The focus of this first part of the two part lecture (Food Micro II is offered in the FS) will be on the organisms, but also on the factors which determine spoilage and foodborne disease.
1. History of Food Microbiology
   1.1. Short synopsis of foodborne microorganisms
   1.2. Spoilage of Foods
   1.3. Foodborne Disease
   1.4. Food Preservation
   1.5. VIP's of Food Microbiology
2. Overview of Microorganisms in Foods
   2.1. Intrinsic and Extrinsic Parameters
   2.2. Bacteria
   2.3. Yeasts
   2.4. Molds
   3. Microbial Spoilage of Foods
      3.1. Intrinsic and Extrinsic Parameters
      3.2. Meats, Seafoods, Eggs
      3.3. Milk and Milk Products
      3.4. Vegetable and Fruit Products
      3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
      3.6. Drinks and Canned Foods
3. Foodborne Disease
   4. Foodborne Disease
      4.1. Significance and Transmission of Foodborne pathogens
      4.2. Staphylococcus aureus
      4.3. Gram-positive Sporeformers (Bacillus & Clostridium)
      4.4. Listeria monocytogenes
      4.5. Salmonella, Shigella, Escherichia coli
      4.6. Vibrio, Yersinia, Campylobacter
      4.7. Brucella, Mycobacterium
      4.8. Parasites
      4.9. Viruses and Bacteriophages
      4.10. Mycotoxins
      4.11. Bioactive Amines
      4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

Credit
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Social Competencies
- Communication
- Personal Competencies
- Creative Thinking
- Critical Thinking

General Biology I+II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Biology I: Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeney.

General Biology II: Molecular biology approach to teach the basic principles of biochemistry, cell biology, cgenetics, evolutionary biology and form and function of vascular plants.

Objective
General Biology I: The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

General Biology II: The understanding basic concepts of biology: the hierarchy of the structural levels of biological organisation, with particular emphasis on the cell and its molecular functions, the fundamentals of metabolism and molecular genetics, as well as form and function of vascular plants.
General Biology I: General Biology I focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogenetic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
29 Diversity of Life Nonvascular&seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

General Biology II: The structure and function of biomacromolecules; basics of metabolism; tour of the cell; membrane structure and function; basic energetics of cellular processes; respiration, photosynthesis; cell cycle, from gene to protein; structure and growth of vascular plants, resource acquisition and transport, soil and plant nutrition.

Specifically the following Campbell chapters will be covered:
3 Biochemistry Chemistry of water
4 Biochemistry Carbon: the basis of molecular diversity
5 Biochemistry Biological macromolecules and lipids
7 Cell biology Cell structure and function
8 Cell biology Cell membranes
10 Cell biology Respiration: introduction to metabolism
10 Cell biology Cell respiration
11 Cell biology Photosynthetic processes
16 Genetics Nucleic acids and inheritance
17 Genetics Expression of genes
18 Genetics Control of gene expression
19 Genetics DNA Technology
35 Plant structure&function Plant Structure and Growth
36 Plant structure&function Transport in vascular plants
37 Plant structure&function Plant nutrition
38 Plant structure&function Reproduction of flowering plants
39 Plant structure&function Plants signal and behavior

Lecture notes
No script

Literature

Prerequisites / notice
Basic general and organic chemistry

This is a virtual self-study lecture for non-German speakers of the *Allgemeine Biology I (551-0001-00L)  and “Allgemeine Biology II (551-0002-00L) lectures. The exam will be written jointly with the participants of this lecture.
### Course Information

**Course:** Consumer Behaviour I

**Enrolment:** Only for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g., incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract:**
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior.

**Objective:**
Students will be able to:
- explain the decision-making processes underlying the purchasing process
- describe the factors that have an influence on consumer behavior
- develop strategies to influence purchasing behavior

**Competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
<td></td>
<td>Social Competencies</td>
<td>Customer Orientation</td>
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</tr>
<tr>
<td></td>
<td>Personal Competencies</td>
<td>Sensitivity to Diversity</td>
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<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
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**Food Science and Nutrition Master - Key for Type**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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**Key for Hours**

<table>
<thead>
<tr>
<th>Symbol</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### 3. Semester

#### Basic Courses II

#### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tbody>
<tr>
<td>402-0063-00L</td>
<td>Physics II</td>
<td>O</td>
<td>5</td>
<td>3V+1U</td>
<td>A. Vaterlaus</td>
</tr>
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</table>

**Abstract**

Introduction to the way physicists think and work with the help of concept questions, demonstration experiments and problem solving. Wherever possible, applications from thermodynamics, electricity and magnetism are taught from the areas of the degree programmes.

**Objective**

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.

**Content**

Thermodynamics with first and second law, phase transformations, transport phenomena. Introduction to electricity and magnetism, as well as waves and modern physics.

**Lecture notes**

A script will be distributed.

**Literature**

Friedhelm Kuypers  
Physik für Ingenieure und Naturwissenschaftler  
Band 2 Elektrizität, Optik, Wellen  
Wiley-VCH, 2012  
ISBN 3527411445, 9783527411443  
(4. Auflage 2022)

**Competencies**

Subject-specific Competencies  
Concepts and Theories assessed  
Techniques and Technologies assessed

Method-specific Competencies  
Analytical Competencies fostered  
Decision-making fostered  
Problem-solving assessed

Social Competencies  
Communication fostered

Personal Competencies  
Self-direction and Self-management fostered

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>701-0071-00L</td>
<td>Mathematics III: Systems Analysis</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>C. Brunner, R. Knutti, H. Wernli</td>
</tr>
</tbody>
</table>

**Abstract**

The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

**Objective**

Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

**Content**

https://iac.ethz.ch/edu/courses/bachelor/vorbereitung/systemanalyse.html

**Lecture notes**

Overhead slides will be made available through the course website.

**Literature**


**Competencies**

Subject-specific Competencies  
Concepts and Theories assessed  
Techniques and Technologies assessed

Method-specific Competencies  
Analytical Competencies assessed  
Problem-solving assessed

Personal Competencies  
Creative Thinking fostered  
Critical Thinking fostered

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>752-4001-00L</td>
<td>Microbiology</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>M. Schuppler, M. La Fortezza, M. Pilhofer, S. Robinson</td>
</tr>
</tbody>
</table>

**Abstract**

Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

**Objective**

Teaching of basic knowledge in microbiology.

**Content**


**Lecture notes**

Wird von den jeweiligen Dozenten ausgegeben.

**Literature**

Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

**Competencies**

Subject-specific Competencies  
Concepts and Theories assessed  
Techniques and Technologies assessed

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-0100-00L</td>
<td>Biochemistry</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>C. Frei</td>
</tr>
</tbody>
</table>

**Abstract**

Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo. Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes. Students are able to describe the structure of proteins/enzymes and are able to explain biochemical functions depending on their 3D structures. Students are able to assess and propose hypothesis how proteins change during evolution.

**Objective**

Connections between several metabolic pathways are known and students can evaluate how one pathway is influence by the activity of another pathway.
Content

Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design. Repetition of basic thermodynamics
Glycolysis, fermentation
The citric acid cycle
Oxidative phosphorylation and ATP physiology

Lecture notes
Horton et al. (Pearson) serves as lecture notes.

Prerequisites / notice
Basic knowledge in biology and chemistry is a prerequisite.

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection

Abstract

Imparts a basic understanding of physiology in mammals, focusing on the fundamental general principles of organ operation in health and disease. This is fostered by discussing all subjects from a functional point of view. A major topic of the lecture is food intake and digestion with its correlated neural and endocrine processes.

Objective

After this course the students are able to describe, explain, and apply basic principles of systems physiology and the mechanisms of the function of the major organ systems.

Competencies

Subject-specific Competencies
Concepts and Theories
Communication
Negotiation

Social Competencies

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection

Abstract

Basics of Organic Chemistry.

Objective

Students will be able to:
• Recall basic organic chemistry reactions, including substitution, elimination and addition reactions occurring at sp2- and sp3-hybridized carbon centers.
• Explain the relative favorability of certain organic chemical structures or certain organic chemical reactions.
• Apply their understanding of reaction mechanism principles to explain observations.
• Differentiate the most reactive sites in a given organic chemical.
• Propose reaction mechanisms to new chemical transformations.

Content

Descriptive chemistry of functional groups (alkyl halides, alkenes, aromatic systems, carbonyls).

Literature

Carsten Schmuck, Basisbuch Organische Chemie, Pearson

Prerequisites / notice
Der Stoff der Basischemie wird vorausgesetzt.

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication

Personal Competencies
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection

Abstract

Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.

Objective

Capacity to learn from data; good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.

Content

Einführung in die Wahrscheinlichkeitsrechnung (Grundregeln, Zufallsvariablen, diskrete und stetige Verteilungen, Ausblick auf Grenzwertsätze), Beschreibende Statistik (einschließlich grafische Methoden). Methoden der Analytischen Statistik: Schätzungen, Tests (einschließlich Binomialtest, t-Test, Vorzeichen-Test, F-Test, Wilcoxon-Test), Vertrauensintervalle, Vorhersageintervalle, Korrelation, einfache und multiple lineare Regression. Einführung in die statistische Programmsprache R.

Lecture notes
Ausführliches Skript zur Vorlesung ist erhältlich.

Literature

Laboratory Course in Physics for Students in Food Sciences

Objective
1. Gain an introductory knowledge of the multi-disciplinary topics comprising Food Science.
2. Understand how the multiple disciplines of food science interrelate in an applied context via guided learning of selected examples of foods and human health.
3. Be prepared to make informed decisions about future steps in the food science education and career.
4. Be able to write a well-structured paragraph.

Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0000-02L</td>
<td>Laboratory Course in Physics for Students in Food Sciences</td>
<td>O</td>
<td>2</td>
<td>4P</td>
<td>A. Bland, A. Eggenberger, A. Müller</td>
</tr>
</tbody>
</table>

Abstract
The central aim is to provide an individual experience of the physical phenomena and the basic principles of the experiment. By conducting simple physical experiments the student will learn how to properly use physical instruments and how to evaluate the results correctly.

Objective
Laboratory work forms an important part of the education in natural sciences. The overhead topic in this lab course is the confrontation of fundamental problems of any experiment. Using the example of simple tasks, the following aspects should be considered in particular:

- the practical structure of the experiment and the knowledge of the measuring methods
- the use and handling of measuring instruments
- the correct evaluation and assessment of the observations
- deepening the knowledge in some areas of elementary physics
- physics as a personal experience.

Content
- Lab safety; error calculation and report writing; 6 selected experiments on a variety of topics. Selection of experiments may vary between courses.

Lecture notes
Manuals for the experiments in the physics lab; additional material is provided on the course website.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Method-specific Competencies
- Communication
- Cooperation and Teamwork

Social Competencies
- Critical Thinking
- Integrity and Work Ethics

Personal Competencies
- fostered

Prerequisites / notice
Only students from 3rd Semester BSc Food Science on are admitted to this Laboratory Course.

Practical Course in Microbiology

Abstract
Basic principles of the handling of microorganisms (MO) - Detection of MO in the environment - Morphology and diagnostics of MO - Morphology and physiology of fungi - Antimicrobial agents - Microbial genetics - Bacterial physiology and interactions - Microbial pest control

Objective
The students are familiar with the laboratory work with microorganisms. Specific emphasis is put on the isolation and maintenance of pure cultures and the required hygiene measures. The students know the clinical and ecological importance of microorganisms.

Content
In an introductory part students are made familiar with the handling and cultivation of microorganisms (MO). Afterwards, the students detect MO in the environment and use MO for the conservation of food. This part is then followed by a practical introduction on routine diagnostics of MO and experiments with antimicrobial agents. On simple experiments, the students experience the interaction of MO with higher organisms - the common topic of all research groups at the Institute of Microbiology. Some simple experiments demonstrate the importance of MO in molecular genetics. The course ends with a short introduction into the fungi and an example of applied microbiology i.e. an experiment on microbial pest control.

Lecture notes
A detailed script of approx. 100 pp. and other relevant documents are available at Moodle at latest 1 week before the beginning of the practical course.

Literature
Recommended literature (facultative):
- Allgemeine Mikrobiologie by Georg Fuchs and Hans G. Schlegel, Thieme-Verlag, 9. Auflage 2014
- Taschenlehrbuch Biologie: Mikrobiologie by Katharina Munk, Thieme Verlag, 2008

Prerequisites / notice
Performance of the students in this practical course is controlled by:

- 1. Attendance of all 7 course days
- 2. Handing in of written reports to selected experiments (in groups of 2 students)
- 3. Preparation of a poster to a selected topic of Microbiology (in groups of 4 students)

Participating doctoral students who collect credit points during their thesis are examined in a 30-minute oral exam at the end of the course.
Basics of Food Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-1000-00L</td>
<td>Food Chemistry I</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>L. Nyström, S. Boulos, M. Erzinger</td>
</tr>
</tbody>
</table>

Abstract
Descriptive chemistry of food constituents (focus on proteins, lipids, carbohydrates).
Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (introduction to lipid oxidation, Maillard reaction).

Objective
Recognize chemical structures of the main ingredients and be able to draw them themselves
Being able to recognize functional groups and assess their properties
Understand chemical reactions and be able to estimate their influence on the quality of a food product
Being able to explain the Maillard reaction and lipid oxidation

Content
Descriptive chemistry of food constituents (focus on proteins, lipids, carbohydrates).
Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (introduction to lipid oxidation, Maillard reaction).
Links to food analysis, food processing, and nutrition.

Topics:
- Structure, properties, reactivity of food ingredients
- Focus: Main ingredients (carbohydrates, proteins, lipids)
- Influence of chemical reactions on food quality
- Introduction Maillard, lipid oxidation
- Selected (possibly changing) food chemistry topics (e.g. baking, milk, flavor, alcoholic beverages, bioactive substances, etc.)

Lecture notes
The lectures Food Chemistry I and Food Chemistry II constitute a unit.

Literature

Basics of Food Science

<table>
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<tr>
<th>Number</th>
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<th>Hours</th>
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<tr>
<td>752-5001-00L</td>
<td>Food Biotechnology</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>N. Bokulich, A. Greppi, B. Pugin</td>
</tr>
</tbody>
</table>

Abstract
Biotechnology is the use of living organisms (or their products) to produce valuable substances or to perform specific services. In this course, you will learn about diverse applications of biotechnology in food and ingredient production, with a focus on microbial biotechnologies.

Objective
In this course you will explore the roles and potential of biotechnology in food production past, present, and future, with a focus on microbial biotechnologies. At the end of this course, you will be able to identify the microorganisms and biotechnologies currently implemented in food and food ingredient production and independently evaluate the potential of biotechnological solutions to current and future food challenges.

Content
The course will cover diverse topics in modern food biotechnology, including:
* food fermentation (arguably the world’s oldest biotechnology)
* the taxonomy and metabolism of microorganisms used in food production
* microbial and fermentation kinetics
* bioreactors for food and ingredient production
* biopreservation
* molecular diagnostics
* safety and regulation of biotechnological ingredients in food production.

At the end of this course, you will be able to identify beneficial/detrimental bacteria associated with food products, execute basic bioinformatic analysis (DNA-based) to identify them, explain the main production (upstream) and purification (downstream) processes of food-relevant microorganisms and ingredients, calculate microbial kinetic parameters, connect key metabolic features with specific application in the food industry (e.g. biopreservation), and understand the general legislation (EU/CH) regarding the use of microorganisms in food.

Literature
A list of references will be given at the beginning of the course for the different topics presented during the course.
### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
<th>Assessed</th>
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<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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### Personal Competencies

<table>
<thead>
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### 752-6001-00L Introduction to Nutritional Science

| W | 3 credits | 2V | I. Herter-Aeberli, K. Giller, C. Wolfrum |

**Abstract**

This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

**Objective**

To introduce the students to both macro- and micronutrients in relation to food and metabolism.

**Content**

The course is divided into two parts: Micronutrients and macronutrients. The micronutrient part includes fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. The macronutrient part introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism. The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeorhesis are emphasized.

**Lecture notes**

There is no script. PowerPoint presentations will be made available.

**Literature**

Elmadfa I & Leitzmann C: Ernährung des Menschen
USB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004

Garrow JS and James WPT: Human Nutrition and Dietetics
Churchill Livingston, Edinburgh, 11th rev. ed. 2005

### 752-4005-00L Food Microbiology I

| W | 3 credits | 2V | M. Loessner, A. Harms |

**Abstract**

This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

**Objective**

The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms. The focus of this first part of the two part lecture (Food Micro II is offered in the FS) will be on the organisms, but also on the factors which determine spoilage and foodborne disease.

**Content**

1. History of Food Microbiology
2. Overview of Microorganisms in Foods
3. Microbial Spoilage of Foods
4. Foodborne Disease
5. Food Preservation
6. VIP's of Food Microbiology
7. Foodborne Pathogens
8. Foodborne Microorganisms
9. Bacteria
10. Yeasts
11. Molds
12. Microbial Spoilage of Foods
13. Intrinsic and Extrinsic Parameters
14. Meats, Seafoods, Eggs
15. Milk and Milk Products
16. Vegetable and Fruit Products
17. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
18. Drinks and Canned Foods
19. Foodborne Disease
20. Significance and Transmission of Foodborne pathogens
21. Staphylococcus aureus
22. Gram-positive Sporeformers (Bacillus & Clostridium)
23. Listeria monocytogenes
24. Salmonella, Shigella, Escherichia coli
25. Vibrio, Yersinia, Campylobacter
26. Brucella, Mycobacterium
27. Parasites
28. Viruses and Bacteriophages
29. Mycotoxins
30. Bioactive Amines
31. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

**Lecture notes**

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

**Literature**

Recommendations will be given in the first lecture.
Food Biotechnology  
Only for Students on the 2016 regulation who did not follow the course Lebensmittel-Verfahrenstechnik I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>752-5001-01L</td>
<td>Food Biotechnology</td>
<td>W</td>
<td>4</td>
<td>2V+1A</td>
<td>N. Bokulich, A. Greppi, B. Pugin</td>
</tr>
</tbody>
</table>

Abstract  
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Objective  
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Content  
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytoxotic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes  
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature  
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice  
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Competencies  
Subject-specific Competencies  
Concepts and Theories  
Techniques and Technologies  
Expertise and Technologies  
Method-specific Competencies  
Analytical Competencies  
Decision-making  
Media and Digital Technologies  
Problem-solving  
Project Management  
Social Competencies  
Communication  
Cooperation and Teamwork  
Self-presentation and Social Influence  
Negotiation  
Personal Competencies  
Adaptability and Flexibility  
Creative Thinking  
Critical Thinking  
Integrity and Work Ethics  
Self-awareness and Self-reflection  
Self-direction and Self-management

Consumer Behaviour I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-2120-00L</td>
<td>Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, A. Bearth, A. Berthold</td>
</tr>
</tbody>
</table>

Abstract  
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

Objective  
Students will be able to,  
- explain the decision-making processes underlying the purchasing process  
- describe the factors that have an influence on consumer behavior  
- develop strategies to influence purchasing behavior

Competencies  
Subject-specific Competencies  
Concepts and Theories  
Analytical Competencies  
Decision-making  
Media and Digital Technologies  
Problem-solving  
Project Management  
Social Competencies  
Communication  
Cooperation and Teamwork  
Customer Orientation  
Self-presentation and Social Influence  
Negotiation  
Personal Competencies  
Adaptability and Flexibility  
Creative Thinking  
Critical Thinking  
Integrity and Work Ethics  
Self-awareness and Self-reflection  
Self-direction and Self-management

Food Chemistry II

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-1003-00L</td>
<td>Food Chemistry II</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>L. Nyström, S. Boulos, M. Erzinger</td>
</tr>
</tbody>
</table>

Abstract  
Descriptive chemistry of food constituents (focus on structure-function relationships). Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (lipid oxidation, Maillard reaction, enzymatic browning).
Objective

Be able to draw chemical structures of the main ingredients, recognize functional groups in the structures and explain their properties. Understand foods as complex systems and be able to make connections between chemical structures, chemical reactions and their influence on quality.

Recognize chemical reactions of lipid oxidation, Maillard reaction and enzymatic reactions and be able to formulate them themselves.

Content

Descriptive chemistry of food constituents (focus on structure-function relationships).

Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (lipid oxidation, Maillard reaction, enzymatic browning).

Links to food analysis, food processing, and nutrition.

Topics:
- Lipid oxidation, Maillard reaction, structural proteins/enzymes
- Food as complex systems
- Chemical reactions and reaction mechanisms
- Selected (possibly changing) food chemistry topics (e.g. sweeteners, polysaccharides, from olive to margarine, etc.)

The lectures Food Chemistry I and Food Chemistry II constitute a unit.

Lecture notes

The lectures are supplemented with handouts.

Literature


S. Gstöhl, Darstellung von Partikelgrößenerverteilungen, Trennen, Zerkleinern, Agglomerieren, Beschreibung von Haufwerken, Haftkräfte, Kapillarphänomene, Sedimentation, Fest Flüssig Trennung

752-2000-00L Food Materials Science W+ 4 credits 3G R. Mezzenga, G. Nyström, M. Radiom

Abstract

Principles of soft condensed matter applied to food polymers, surfactants and colloids

Objective

Students will be able to:

- Describe the fundamental physical principles ruling the self-assembly, aggregation, processing and structure-properties relationship in food systems constituted by polysaccharides (polymers), proteins (colloids) and lipids (surfactants).
- Assess and recommend the best set of parameters controlling structure in foods
- Integrate physical and chemical principles to optimize food properties to meet specific requirements of defined food products

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Media and Digital Technologies assessed

Problem-solving assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

752-6307-00L Food, Habits and Health W 3 credits 2V D. Burdakov, D. Peleg-Rabstein

Abstract

Imparts an advanced understanding of physiology, focusing on the link between nutrition and function of the mammalian organism. This is fostered by discussing all subjects from a viewpoint of health and disease. A major topic of the lectures is the link between nutrition and brain function, including mental health and neurodegenerative disorders.
Objectives At the end of the course, the students are able to describe, explain, and apply the biological and nutritional principles of physiology including specific examples relating to brain functions.

Lecture Notes Handouts for each topic will be made available on Moodle.

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Communication: fostered
- Negotiation: fostered
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered

Social Competencies

- Communication: fostered
- Negotiation: fostered

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered

Lecture Notes Handouts for each topic will be made available on Moodle.

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Communication: fostered
- Negotiation: fostered
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered

Method-specific Competencies

- Analytical Competencies: fostered
- Problem-solving: fostered
- Communication: fostered
- Cooperation and Teamwork: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered

Personal Competencies

- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

Prerequisites / Notice

This course is a prerequisite for the course Financial Management.

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: fostered
- Problem-solving: fostered

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered

Personal Competencies

- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

Prerequisites / Notice

This course is a prerequisite for the course Financial Management.

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<td>W</td>
<td>3</td>
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Abstract
Teaching of basic experimental knowledge for detection and identification of relevant microorganisms in food. Various practical experiments were accompanied by theoretic introductions to the different topics. The students become acquainted with state-of-the-art methods with main focus on modern molecular techniques for the rapid detection of food borne pathogens.

Autumn Semester 2024
Die Studierenden
- setzen im Studium erworbenes und im Rahmen der Lehrveranstaltung neu erarbeitetes Wissen ein, um zu beurteilen, welche Mikroorganismen in welchen Lebensmitteln relevant sind.
- können entscheiden, welche Verfahren zum Nachweis welcher Mikroorganismen geeignet sind.

Überfachliche Lernziele
Die Studierenden
- evaluieren und bewerten ihre Ergebnisse vor dem Hintergrund der verwendeten Methoden.
- dokumentieren ihre Tätigkeiten in einem Laborjournal in übersichtlicher Form und diskutieren die erhaltenen Ergebnisse kritisch.

Content
Grundtechniken für die mikrobiologische Untersuchung von Lebensmitteln, Qualitätssicherung, Anwendung von antimikrobiellen Wirkstoffen, Nachweismethoden für die wichtigsten pathogenen Keime aus Lebensmitteln und einzelnen Keimen aus fermentierten oder probiotischen Lebensmitteln mit klassischen Methoden (u.a., Anreicherungssysteme, ELISA, Enzymsysteme) und Methoden der Molekularbiologie (PCR, Hybridisierung, in situ-Nachweis), Durchführung von Gentransfermethoden mit Mikroorganismen (Konjugation, Transformation) und Bakteriophagen in Lebensmitteln

Lecture notes
Wird am Praktikumsanfang abgegeben.

Literature
- Krämer: "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
- Süssmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)

Prerequisites / notice
During the course we will work with the food-borne pathogen Listeria monocytogenes. Listeria monocytogenes represents a particular threat in case of pregnancy. Due to biosafety reasons participation is not allowed in case of pregnancy.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Cooperation and Teamwork

Social Competencies
Communication

Personal Competencies
Critical Thinking

752-2002-00L Food Technology Laboratory Course W 2 credits 4P H. Adelmann
Prerequisite: Attendance of the course 752-2001-00L "Food Technology".

Abstract
Practical laboratory work on pilot plant scale on important processes for selected foods from the raw material to the final product. Evaluation of food quality.

Objective
Know how and handling of the production from selected manufacturing processes to the preservation of food. Understanding the effects of important parameters to the preservation of food including the evaluation of the raw material and the intermediate as well as final products; Analyzing the effects with defined manufacturing processes on the quality of the final products; Evaluation of scientific and non-scientific information and sources.

Content
This practical course contains different experimental blocks:
- Production of sterile canned goods, determination of sterilization conditions (obligation for all studying)
- Production of long paste goods (humidification, drying process and Characteristic)
- Production and processing of meat-loaf (employment of nitrite salts and their effect)
- Production of potato flakes (Characteristic of the ingredients among other things content of strength and drying process)
- Production of Tofu (from the soy bean to finished Tofu)
- Hot extruding of corn semolina
- Characteristic of wheat flour and production of bread (paste preparing/computations and various analyses)

Lecture notes
All information and the program will be sent to enrolled students prior to the start of the laboratory course by e-mail. The scripts for this course on the page of the course catalogue in learning materials are available online and can be viewed after login.

Literature
References are given in the manuscript.

Prerequisites / notice
Prerequisite is the participation in the course 752-2001-00L Food Technology.

азв Electives
A list with possible electives will be published separately.

Number Title Type ECTS Hours Lecturers
Food Science General Courses can be accounted as electives as well.


Abstract
This course explores the mechanisms that govern the adaptive functions of out-of-equilibrium systems in living organisms at the molecular scale and the microstructural design principles of biological materials at larger length scales. Throughout the course, we will also explore how these design principles can be incorporated into synthetic systems to improve targeted functions.

Objective
By the end of this course, students will be able to explain how natural selection optimizes biological materials at the molecular and microstructural levels and how this optimization process has resulted in the emergence of biological design principles that fulfill essential functions for species' survival. Students will gain the ability to analyze and integrate bio-inspired adaptive functions into synthetic material systems, as well as interpret the correlation between function, microstructure, and performance of biological and bio-inspired materials. Through engaging activities, students will also develop strategies to create bio-inspired solutions for typical engineering problems and predict the performance of bio-inspired materials.
This course is divided into two main blocks. The first block focuses on the primary molecular adaptations of living organisms, while the second block covers the fundamental microstructural design principles present in biological materials.

**Block I: Molecular Adaptations of Living Organisms and Creation of Adaptive Bio-inspired Materials**

- Temporal regulation in biological and bio-inspired molecular systems;
- Autonomous molecular structures and out-of-equilibrium systems;
- Molecular motion and work generation mechanisms in biological and bio-inspired systems;
- Sensing, adaptation, and communication in biological and bio-inspired material systems;

**Block II: Principles of Microstructural Design in Biological Materials and Their Synthetically Engineered Counterparts**

- Fundamentals of engineering in biological and bio-inspired materials;
- Replicating biological design principles in synthetic materials (structural, optical, surface properties, etc.);
- Bio-inspired design and systems (mechanical actuation and bio-inspiration in the built environment);

**Lecture notes**
Copies of the slides will be made available for download before each lecture.

**Literature**
The course is mainly based on the references listed below. Additional references will be provided during the lectures.


**Competencies**

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**535-0230-00L Medicinal Chemistry I**

**Abstract**
The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

**Objective**
Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

**Content**
Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions

**Lecture notes**
Will be provided in parts before each individual lecture.

**Literature**

**Prerequisites / notice**
Requirements: Knowledge of physical and organic chemistry, biochemistry and biology. Attendance of Medicinal Chemistry II in the spring semester.

**Compencies**

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**851-0626-01L International Development Cooperation**

**Abstract**
The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.

**Objective**
Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid. Students are able to critically discuss the various aid instruments of bi-and multilateral donors and NGOs.

**Content**
Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid: e.g. Micro-Finance, Budget-Support; Fair-Trade.

**Literature**
Articles and book abstracts will be uploaded to a course website.

**363-0387-00L Corporate Sustainability**

**Abstract**
Does not take place this semester.

**Objective**
Student have a theoretically and empirically sound understanding of the prospects and limitations of international development aid.

**Content**
Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid: e.g. Micro-Finance, Budget-Support; Fair-Trade.

**Literature**
Articles and book abstracts will be uploaded to a course website.
Objective

Students
- assess the limits and the potential of corporate sustainability for sustainable development
- develop competencies that are useful in the context of corporate sustainability and beyond (analytical competency, critical thinking, problem solving)
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams

The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. The module combines asynchronous videos, live sessions, with a group work phase between weeks 5-10 of semester during which students deep-dive into one of 10 sustainability challenges.

Content

Corporate Sustainability is the flagship course of the Group for Sustainability and Technology at D-MTEC. In this course, students learn about key concepts in corporate sustainability and develop skills to implement them in the real world. The course prepares students for making well-informed sustainability decisions in their future careers.

The course uses constructive alignment to bring the various innovative teaching and learning elements (e.g., case-based experiential learning, reflective thinking and blended learning with videos and quizzes) into a coherent transformational journey. Students can now flexibly, effectively and efficiently acquire the conceptual foundations that are essential for a substantial understanding of corporate sustainability.

For part of the course, students work in groups to complete a set of graded assignments designed to guide them into a deep dive on a selected corporate sustainability challenge. Please note that full participation in this part is essential, so make sure you are available. Furthermore, these group assignments count towards the overall grade for the course.

For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

860-0023-00L International Environmental Politics

Abstract

This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined.

Objective

The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

Content

This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

Lecture notes

Presentation slides will be made available on Moodle after lectures.

Literature

Literature recommendations will be distributed via Moodle, and are available from the start of the course.

Prerequisites / notice

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

Credits and Exam

After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. Students who obtain a grade of < 4.0 for the test will have a second chance (see table below). Students who did not participate in the test on 18 December 2023 will not have access to the repeat test unless they submit compelling and documented (e.g. medical, other exam in parallel at ETH) reasons for why they were unable to participate in the first test. It covers all contents of the lectures and the reading assignments. Visiting students (e.g., from the University of Zurich or other universities) are subject to the same conditions. Registration for the course in the mystudies system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Problem-solving
- Critical Thinking
- Self-awareness and Self-reflection

Method-specific Competencies
- Decision-making
- Cooperation and Teamwork
- Negotiation

Social Competencies
- Communication

Personal Competencies
- Creative Thinking

Prerequisites / notice

Access / Prerequisites

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

Credits and Exam

After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. Students who obtain a grade of < 4.0 for the test will have a second chance (see table below). Students who did not participate in the test on 18 December 2023 will not have access to the repeat test unless they submit compelling and documented (e.g. medical, other exam in parallel at ETH) reasons for why they were unable to participate in the first test. It covers all contents of the lectures and the reading assignments. Visiting students (e.g., from the University of Zurich or other universities) are subject to the same conditions. Registration for the course in the mystudies system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.
Abstract
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective
The students shall obtain the following competence:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes
A comprehensive script will be made available online on the moodle platform.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed

Social Competencies
- Communication: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered


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Abstract
The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction to specialized project management software as well as agile project management concepts.

Objective
Projects are not only the base of work in modern enterprises, but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company-wide success.

Content
The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project. Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

Lecture notes
No

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: assessed

Personality Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed


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Abstract
The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms competitive strategies and marketing priorities.

Objective
After completing this course:
1. Students can explain the importance of supply chain management for a firm’s strategy and success
2. Students are able to apply the tools and methods used to optimize a supply chain structure
3. Students can differentiate supply chain network designs and their applicability in specific company and sector settings
4. Students can describe and evaluate fundamental logistics and supply chain concepts
5. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy
6. Students are familiar with current developments and trends in supply chain practices

Content
Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage in globalized (supply) markets with numerous partners and competitors. While taking into account future opportunities and risks, effective supply chains have to be aligned with and support the achievement of the firm’s corporate, business and product strategies. This course will familiarize students with modern supply chain management theory and practice to develop and manage supply chains. Starting with the corporate strategy, firms align their supply chain strategy. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain’s role within a firm and the implications of supply chain strategies for firm performance are the foundations of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management and transportation. At the same time, supply chain management is inevitably cross-functional. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge.

The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.
The lecture deals with problems of tumor epidemiology (causes, mortality, incidence). Cancer is delineated as a multi-step process.

Adaptability and Flexibility

The course material will be made available for download on Moodle:

https://moodle-app2.let.ethz.ch/course/view.php?id=20606

All organizational matters will be handled by the teaching assistant Yan Zou (yanzou@ethz.ch). Please use the SSCM Class Forum on Moodle as a first point of contact.

Prerequisites / notice

Students should install MS Excel and the Excel Solver before class, as it is used for within-class exercises. Students without the program and add-in installed may nevertheless participate within groups during the exercises.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Method-specific Competencies

Social Competencies

- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract

The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective

On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Literature


The following textbook is supplementary:

**Ethics of Life Sciences and Biotechnology**

**376-1661-00L**

**Abstract**

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

**Objective**

- A. Identify ethical issues in in life sciences and biotechnology.
- B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
- C. Become aware of relevant legal and public policy frameworks.
- D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
- E. Recognize how ethical issues relate to different accounts of technology and innovation.
- F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
- G. Autonomously anticipate ethical issues.
- H. Propose and communicate solutions to ethical challenges and dilemmas.

**Content**

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

**Competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>fostered</td>
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<tr>
<td>Techniques and Technologies</td>
<td>fostered</td>
<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
<td>fostered</td>
<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>fostered</td>
<td>assessed</td>
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<td>assessed</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td>fostered</td>
<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Problem-solving</td>
<td>fostered</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Communication</td>
<td>assessed</td>
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<td>assessed</td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>assessed</td>
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<tr>
<td>Customer Orientation</td>
<td>fostered</td>
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<td>assessed</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>fostered</td>
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<td>assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>assessed</td>
<td>fostered</td>
<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
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<td>assessed</td>
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<tr>
<td>Negotiation</td>
<td>fostered</td>
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<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<tr>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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<td>assessed</td>
<td>assessed</td>
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</tbody>
</table>

**Introduction to Pharmaceutical Sciences I**

**535-0001-00L**

**Abstract**

First identification with Pharmaceutical Sciences; motivation for profiling in the Natural Sciences, which are focused on within the first two years as a preparation for the specialized studies; sensitization for the duties and the responsibilities of a person with a federal diploma in Pharmacy; information about job opportunities.

**Objective**

First identification with Pharmaceutical Sciences; motivation for profiling in the Natural Sciences as a preparation for the specialized studies; sensitization for the duties and the responsibilities of a person with a federal diploma in Pharmacy; information about job opportunities.

**Content**

Introduction to Pharmaceutical Sciences by selected milestones of research and development. Overview on research activities at the Institute of Pharmaceutical Sciences that is focussed on drug delivery and development (from concepts to prototypes). Sensitization for communication skills and information management. Demonstration of job opportunities in community pharmacies, in the hospital, in industry, and in the public sector by experts in the different fields.
Bachelor Studies (Programme Regulations 2024)

1st semester

First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0251-00L</td>
<td>Mathematics I</td>
<td>O</td>
<td>6</td>
<td>V+U</td>
<td>A. Cannas da Silva</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.</td>
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<tr>
<td></td>
<td>2. Linear Algebra and Complex Numbers: systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.</td>
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<td></td>
<td>3. Ordinary Differential Equations: separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.</td>
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<tr>
<td></td>
<td>- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: familiarity with the basic notions from Calculus, in particular those of function and derivative.</td>
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<tr>
<td></td>
<td>Skripte und zusätzliches Lernmaterial werden auf Moodle verfügbar gemacht.</td>
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</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Die Grundlagen des Weltführungs- und Ernährungssystems werden erarbeitet und vertieft. Das Wissen bietet einen guten Hintergrund für weiterführende Studien.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Mit Besuch dieser Lehrveranstaltung soll Verständnis geschaffen werden, was ein Weltführungs- und Ernährungssystem ist, wo aktuell die grossen Herausforderungen liegen, was Elemente und Einflussfaktoren auf die Ernährungssicherheit sind, welche Wechselwirkungen zwischen diesen Elementen und Einflussfaktoren bestehen und welche potentiellen Lösungsstrategien sich für spezifische Herausforderungen ableiten lassen.</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>Skripte und zusätzliches Lernmaterial werden auf Moodle verfügbar gemacht.</td>
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</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Economics</th>
<th>O</th>
<th>3</th>
<th>G</th>
<th>U. Renold, T. Bolli, P. McDonald, F. Pusterla, A. Zubovic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Not for students belonging to D-MTEC! This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.</td>
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</table>

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1570 of 2667
Objective: After successful completion of the course you will be able to:
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Content: Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

Lecture notes: no script available


Prerequisites / notice: Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.

Competencies:

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: assessed

- Method-specific Competencies
  - Critical Thinking: assessed
  - Self-direction and Self-management: assessed

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 credits</td>
<td>2V+1U</td>
<td></td>
<td>U. Sauer, O. Y. Martin, A. Widmer</td>
</tr>
</tbody>
</table>

401-0624-00L Mathematics IV: Statistics

Abstract: Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.

Objective: Capacity to learn from data; good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.


Lecture notes: Ausführliches Skript zur Vorlesung ist erhältlich.


Prerequisites / notice: Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

Voraussetzungen: Mathematik I, II

First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0001-00L General Biology I</td>
<td>O</td>
<td>3</td>
<td>3V</td>
<td>U. Sauer, O. Y. Martin, A. Widmer</td>
<td></td>
</tr>
</tbody>
</table>

Abstract: Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny. First in a series of two lectures given over two semesters for students of agricultural and food sciences, as well as of environmental sciences.

Objective: The understanding of some basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

Content: The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
- 12 Cell biology: Mitosis
- 13 Genetics: Sexual life cycles and meiosis
- 14 Genetics: Mendelian genetics
- 15 Genetics: Linkage and chromosomes
- 20 Genetics: Evolution of genomes
- 21 Evolution: How evolution works
- 22 Evolution: Phylogenetic reconstructions
- 23 Evolution: Microevolution
- 24 Evolution: Species and speciation
- 25 Evolution: Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
- 26 Diversity of Life: Introduction to viruses
- 27 Diversity of Life: Prokaryotes
- 28 Diversity of Life: Origin & evolution of eukaryotes
- 29 Diversity of Life: Nonvascular/seedless vascular plants
- 30 Diversity of Life: Seed plants
- 31 Diversity of Life: Introduction to fungi
- 32 Diversity of Life: Overview of animal diversity
- 33 Diversity of Life: Introduction to invertebrates
- 34 Diversity of Life: Origin & evolution of vertebrates
The lecture is the first in a series of two lectures given over two semesters for students with biology as a basic subject.

529-2001-02L Chemistry I

Abstract

General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course "Chemistry I", the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, tested, and examined.

Objective

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content

1. Stoichiometry
   - Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
4. Basics of chemical thermodynamics
   - System and surroundings. Description of state and change of state of chemical systems.
5. First law of thermodynamics
6. Second law of thermodynamics
   - Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. Gibbs energy and chemical potential.
8. Chemical equilibrium
9. Acids and bases
10. Dissolution and precipitation.
    - Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes

Online-Skript mit durchgerechneten Beispielen.

Literature


Weiterführende Literatur:


Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Additional First Year Courses

Number Title
252-0839-00L Informatics

Abstract

Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists, tables and relational databases, introduction to programming.

Objective

The students learn to...

- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data,
- query databases and understand and evaluate the corresponding database model,
- encode a problem into a program, test the program, and correct errors,
- implement models from the natural sciences as a simulation.

Content

1. Modeling and simulations
2. Data management with lists and tables
3. Data management with a relational database
4. Introduction to programming with Python 1 (variables & data types)
5. Introduction to programming with Python 2 (control structures & logic)
6. Introduction to programming with Python 3 (sequential data structures)

Lecture notes

All materials for the lecture are available at www.evim.ethz.ch

Literature

This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

**Prerequisites / notice**

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories fostered
- Techniques and Technologies assessed

**Method-specific Competencies**
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management fostered

**Social Competencies**
- Communication assessed
- Cooperation and Teamwork fostered

**Personal Competencies**
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

**751-0801-00L Fundamentals of Microscopy and Plant Biology**

**Abstract**

**Objective**
Capability of preparing biological specimen, microscopy and documentation. Understanding the correlation between plant structure and function at the level of organs, tissues and cells. Awareness of the link between plant anatomy, systematics, physiology, ecology, and development.

**Content**

**Lecture notes**
Online in Moodle Course

**Literature**
For further reading (not obligatory):
Gerhard Wanner: Mikroskopisch-Botanisches Praktikum, Georg Thieme Verlag, Stuttgart.

**Prerequisites / notice**
Groups of a maximum of 20 students.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories fostered

**Method-specific Competencies**
- Analytical Competencies fostered

**Social Competencies**
- Communication fostered

**Personal Competencies**
- Critical Thinking fostered

**Scientific in Perspective**
**Recommended Science in Perspective (Type B) for D-HEST**

**Language Courses**
see Science in Perspective: Language Courses ETH/UZH

**Bachelor's Thesis**
see Science in Perspective: Language Courses ETH/UZH

**Number**
**Title**
**Type**
**ECTS**
**Hours**
**Lecturers**

752-0220-20L Bachelor's Thesis O 15 credits 32D Lecturers

**Abstract**
The Bachelor Thesis completes the Bachelor programme and consists of a scientific project carried out independently under the tutorship of a lecturer at D-HEST.

**Objective**
The Bachelor Thesis aims at fostering the student's ability to independent, structured and scientific working and at deepening their knowledge in a specific field.

**Food Science and Nutrition Bachelor - Key for Type**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E+</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS** European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will be used to illustrate these sessions. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Problem-solving: assessed

Method-specific Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

Abstract
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

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Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Method-specific Competencies
- Communication: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

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Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Method-specific Competencies
- Communication: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

Abstract
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

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All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Method-specific Competencies
- Communication: assessed
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Competencies
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- Concepts and Theories: assessed
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Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
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Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Method-specific Competencies
- Communication: assessed
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Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Method-specific Competencies
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- Critical Thinking: assessed
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All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Method-specific Competencies
- Communication: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

Abstract
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.
This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models. They acquire the ability to apply these models in the interpretation of real world economic contexts.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature

Prerequisites / notice
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

351-0511-00L Managerial Economics Z 4 credits 3V O. Krebs, P. Egger, M. Köthenbürger
Not for MSc students belonging to D-MTEC!

Abstract
"Managerial Economics" provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

Objective
The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

Literature

Prerequisites / notice
The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

Competencies
Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed

351-1034-00L Microeconomics ■ Z 3 credits 2V A. Fetz, M. Gysler
Not for students belonging to D-MTEC!

Abstract
Introduction to the economic decisions of households and firms, and their coordination through markets. Analysis of different market structures and of situations in which markets may lead to socially undesirable outcomes.

Objective
Understanding of basic microeconomic models. Ability to apply these models to real world economic situations.

Content
Economics as a science, division of labour and welfare (concept of comparative advantage), supply and demand (market equilibrium, elasticity), households (preferences, demand), firms (technology, cost analysis, profit maximisation, supply), perfect competition, monopoly and oligopoly, externalities, public goods, information, factor markets and income distribution

Lecture notes
via email

Literature
Mankiw, G. and Taylor M. (2023): Economics, Cengage Learning

Prerequisites / notice
Course macroeconomics in the spring term
## Competencies

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<thead>
<tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

### 351-0555-00L  
**Open- and User Innovation**  
Not for students belonging to D-MTEC!

**Abstract**  
The course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.

**Objective**  
The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active class participation is required.

**Content**  
This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

**Lecture notes**  
The slides of the lectures are made available and updated continuously through Moodle.

**Literature**  
Relevant literature for the course includes slides and reading assignments. Papers will be made available through a corresponding Moodle group.

### 351-1158-00L  
**Economics**  
Not for students belonging to D-MTEC!

**Abstract**  
This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

**Objective**  
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

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Autumn Semester 2024  
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Content

Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

Literature


Competencies

Subject-specific Competencies

Concepts and Theories  assessed

Method-specific Competencies

Analytical Competencies  assessed

Decision-making  assessed

Problem-solving  assessed

Personal Competencies

Critical Thinking  assessed

Self-direction and Self-management  assessed

351-1158-AAL  Principles of Economics

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Students understand basic microeconomics and macroeconomics problems and theories. They are able to argue along economic principles and to judge policy measures.

Objective

Upon successful completion of the course, you will be able to:

- Describe the basic microeconomic and macroeconomic problems and theories.
- Make economic arguments to a given topic.
- Evaluate economic measures.

Content

Households, firms, supply and demand: How are household preferences and consumption behavior formed? How does a household react to price changes? How are goods prices formed? At what prices are firms willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How do we make economic decisions?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labor market? What influences unemployment?

National Accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work, and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society.

Literature


Competencies

Subject-specific Competencies

Concepts and Theories  assessed

Personal Competencies

Self-direction and Self-management  assessed

Management, Technology and Economics (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Level</th>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>Z</td>
<td>3</td>
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<tr>
<td>Dr</td>
<td>6</td>
<td>eligible for credits and recommended</td>
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<tr>
<td>E-</td>
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Key for Hours

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<thead>
<tr>
<th>Level</th>
<th>Description</th>
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<tr>
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<td>U</td>
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<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
ECTS fostered

The course Accounting for Managers offers an introduction to financial and managerial accounting, especially for students who aspire for a career in business and management with a science or engineering background.

Objectives
- understand the accounting system, the reporting process, and be able to prepare financial statements
- feel comfortable reading and using the information presented in companies’ annual reports
- understand cost concepts and conduct cost analyses
- become familiar with several classic decisions using managerial accounting information
- comment on the current events related to these topics

Content
Accounting plays a critical role in the effective functioning of the financial market as well as the long-term success of a company. This course intends to provide an introduction to accounting for those who wish to pursue a career in business, and need the skills and knowledge to understand, analyze, and interpret accounting information to make informed decisions. The course is divided into two parts. In the first part, we focus on financial reporting and start with the basic accounting concepts and the accounting cycle, to learn how the financial system is set up in a company and how financial statements are prepared. We then delve deeper into each major account, and discuss how revenues and expenses are recognized, and how assets, liabilities, and equities are reported. In the second part, we focus on managerial accounting for internal managerial/operational decisions including fundamental topics such as cost behavior, cost estimation, CVP analyses, and relevant costing. We then cover budgeting and standard costing, which are important parts of accounting system in companies.

Prerequisites / notice
This course is a prerequisite for the course Financial Management.

Core Courses

Financial Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<td>W+</td>
<td>3</td>
<td>2V</td>
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Abstract
The course Accounting for Managers offers an introduction to financial and managerial accounting, especially for students who aspire for a career in business and management with a science or engineering background.

Objective
After attending the class, you should be able to:
- understand the accounting system, the reporting process, and be able to prepare financial statements
- feel comfortable reading and using the information presented in companies’ annual reports
- understand cost concepts and conduct cost analyses
- become familiar with several classic decisions using managerial accounting information
- comment on the current events related to these topics

Content
Accounting plays a critical role in the effective functioning of the financial market as well as the long-term success of a company. This course intends to provide an introduction to accounting for those who wish to pursue a career in business, and need the skills and knowledge to understand, analyze, and interpret accounting information to make informed decisions. The course is divided into two parts. In the first part, we focus on financial reporting and start with the basic accounting concepts and the accounting cycle, to learn how the financial system is set up in a company and how financial statements are prepared. We then delve deeper into each major account, and discuss how revenues and expenses are recognized, and how assets, liabilities, and equities are reported. In the second part, we focus on managerial accounting for internal managerial/operational decisions including fundamental topics such as cost behavior, cost estimation, CVP analyses, and relevant costing. We then cover budgeting and standard costing, which are important parts of accounting system in companies.

General Management and Human Resource Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This course is an introduction to general management. This course follows a systemic view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations.

Objective
By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations to achieve their goals and to coordinate operations in order to meet evolving customers’ and societal needs. The students will achieve these goals by being able to:
- Analyze organizations as open systems, and describe their critical elements,
- Apply conceptual tools and methods that help to analyze or approach the critical elements,
- Compare different notions of organizational performance, and explain why they matter,
- Discuss the relationships that connect the critical elements of an organization on the basis of real cases,
- Explain how change, internally or externally initiated, impact such relationships

Content
This course is an introduction to general management. This course follows a ‘systemic’ view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations: Input (i.e., from external environment), strategy, people, work, formal and informal structure of the organization, and its outputs. In this course we will introduce these critical elements and learn how managers can analyze and approach these elements by means of different conceptual tools and methods in order to achieve performance. We will furthermore discuss the relationships that connect the critical elements together by means of real-life cases, whereby the focus will be on the critical reflection of particular cases of fits and misfits between those elements and on the application of a selection of tools and methods.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

Social Competencies
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered

Prerequisites / notice
This course is a prerequisite for the course Financial Management.

Lecture notes
The content of the course will rely on different readings, cases and selected chapters of following book:

Selected readings from the book and additional learning materials will be available on the course Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=20842

Literature
The content of the course will rely on different readings and on selected chapters of following book:

Selected readings from the book and additional learning materials will be available on the course Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=20842

Prerequisites / notice
This course is a prerequisite for the course Financial Management.

The final exam is requested for all types of students (BSc, MSc, MAs, PhD, and Exchange students). It is not possible to retake the exam within the same term or academic year.
We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.
### Management of Digital Transformation

#### Number
- 363-0421-00L

#### Title
- Management of Digital Transformation

#### Type
- W+ 3 credits

#### Hours
- 2G

#### Lecturers
- E. Fleisch

#### Abstract
This course provides an overview of Digital Transformation within organizations, the opportunities that come with it, but also the issues managers face transforming their organizations into the digital age. Increasingly, information technology (IT) is not only being used as a tool to improve processes but to also create and capture new customer value and to gain and maintain competitive advantage.

#### Objective
This course introduces to the students the relevant subjects that form the digital transformation agenda of organizations' top-level management. After completing the 4 core learning blocks below, students will be able understand, analyze, and critically question organization's digital transformation processes while also learning the frameworks and tools used by organizations to digitally transform.

1. Digital transformation strategies
2. Organizing the digital transformation
3. Digital transformation and technology
4. Digital transformation within industries

Throughout the course, students will learn from and discuss with guest lecturers their experiences of digital transformation.

#### Content
Digital Transformation has become a top management theme across all industries. It is part of the strategic agenda of management and supervisory boards with dedicated roles to drive forward its design and implementation.

The lecture introduces many of the relevant subjects that together form the digital transformation agenda of organizations' top-level management. It establishes the main themes, tools, and theoretical concepts. The lecture consists of 4 learning blocks, each with a focus on an area of Digital Transformation, and will feature guest lecturers from industry. The lecture is structured as follows:

**Block 1: Strategy**
- Digital Business Model Patterns
- Platform Companies
- Subscription Models
- Lessons from Theory Toolbox

**Block 2: Organizational**
- Towards an Agile Organization

**Block 3: Technology**
- "Future-proof" Infrastructure

**Block 4: Industry**
- Digital Transformation in the Health Care Industry
- Digital Transformation in the Automotive Industry

The course is divided into an onsite classroom part and an online self-learning part. All teaching materials will be available through the course page on Moodle.

#### Lecture notes
All lecture content is provided via the Moodle platform.

#### Literature
All relevant literature is provided via the Moodle platform.

#### Competencies

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### Production and Operations Management

#### Number
- 363-0445-00L

#### Title
- Production and Operations Management

#### Type
- W+ 3 credits

#### Hours
- 2G

#### Lecturers
- T. Netland

#### Abstract
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

#### Objective
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1579 of 2667
The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms' competitive strategies and marketing priorities. This course is administered via Moodle. The course is designed around five elements:

2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage. The course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM, Performance management, Performance improvement, Quality management, and Maintenance.

The following textbook is recommended:

The following textbook is supplementary:

All organizational matters will be handled by the teaching assistant Yan Zou (yanzou@ethz.ch). Please use the SSCM Class Forum on Moodle as a first point of contact.

The course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM, Performance management, Performance improvement, Quality management, and Maintenance.

Literature

Suggested literature is provided in the syllabus.

Competencies

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363-0453-00L Strategic Supply Chain Management

W+ 3 credits 2G S. Wagner

Abstract

The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms' competitive strategies and marketing priorities.

Objective

After completing this course:
1. Students can explain the importance of supply chain management for a firm’s strategy and success
2. Students are able to apply the tools and methods used to optimize a supply chain structure
3. Students can differentiate supply chain network designs and their applicability in specific company and sector settings
4. Students can describe and evaluate fundamental logistics and supply chain concepts
5. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy
6. Students are familiar with current developments and trends in supply chain practices

Content

Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage in globalized (supply) markets with numerous partners and competitors. While taking into account future opportunities and risks, effective supply chains ought to be aligned with and support the achievement of the firm's corporate, business and product strategies. This course will familiarize students with modern supply chain management theory and practice to develop and manage supply chains. Starting with the corporate strategy, firms align their supply chain strategy. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain's role within a firm and the implications of supply chain strategies for firm performance are the foundations of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management and transportation. At the same time, supply chain management is inevitably cross-functional. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge.

The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.

Lecture notes

The course material will be made available for download on Moodle:
https://moodle-app2.let.ethz.ch/course/view.php?id=20606

All organizational matters will be handled by the teaching assistant Yan Zou (yanzou@ethz.ch). Please use the SSCM Class Forum on Moodle as a first point of contact.

The following textbook is recommended:

The following textbook is supplementary:

Prerequisites / notice

Students should install MS Excel and the Excel Solver before class, as it is used for within-class exercises. Students without the program and add-in installed may nevertheless participate within groups during the exercises.
### Competencies

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### Micro and Macroeconomics

#### 363-0565-00L Principles of Macroeconomics

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<th>Number</th>
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<td>W+</td>
<td>3 credits</td>
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<td>J.-E. Sturm</td>
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**Abstract**

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

**Objective**

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

**Content**

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

**Lecture notes**

The course Moodle page contains announcements, course information and lecture slides.

**Literature**


This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

#### Competencies

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#### 363-0503-00L Principles of Microeconomics

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**Abstract**

The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

**Objective**

The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics. 
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs. 
3. Students can contrast different market structures and describe firm and consumer behaviour. 
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. 
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. 
6. Students can apply simple mathematical concepts on economic problems.
## Content

The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

### Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

### Lecture notes

Lecture notes, exercises and reference material can be downloaded from Moodle.

### Literature


For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book: N. Gregory Mankiw and Mark P. Taylor (2023), "Microeconomics", 6th edition, South-Western Cengage Learning.

### Prerequisites / notice

Complementary:


GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

## Competencies

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### Reference Books


For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book: N. Gregory Mankiw and Mark P. Taylor (2023), "Microeconomics", 6th edition, South-Western Cengage Learning.

### Abstract

Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

### Objective

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

### Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

### Literature

The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their stakeholders. The module combines asynchronous videos, live sessions, with a group work phase between weeks 5-10 of semester during which students deep-dive into one of 10 sustainability challenges.

The course explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. The module combines asynchronous videos, live sessions, with a group work phase between weeks 5-10 of semester during which students deep-dive into one of 10 sustainability challenges.

The course uses constructive alignment to bring the various innovative teaching and learning elements (e.g., case-based experiential learning, reflective thinking and blended learning with videos and quizzes) into a coherent transformational journey. Students can now flexibly, efficiently, and effectively acquire the conceptual foundations that are essential for a substantial understanding of corporate sustainability.

For part of the course, students work in groups to complete a set of graded assignments designed to guide them into a deep dive on a selected corporate sustainability challenge. Please note that full participation in this part is essential, so make sure you are available. Furthermore, these group assignments count towards the overall grade for the course.

For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

**Objective**

- assess the limits and the potential of corporate sustainability for sustainable development
- develop competencies that are useful in the context of corporate sustainability and beyond (analytical competency, critical thinking, problem solving)
- recognize and realize opportunities through teamwork for corporate sustainability in a business environment
- present strategic recommendations in teams

**Content**

Corporate Sustainability is the flagship course of the Group for Sustainability and Technology at D-MTEC. In this course, students learn about key concepts in corporate sustainability and develop skills to implement them in the real world. The course prepares students for making well-informed sustainability decisions in their future careers.

The course uses constructive alignment to bring the various innovative teaching and learning elements (e.g., case-based experiential learning, reflective thinking and blended learning with videos and quizzes) into a coherent transformational journey. Students can now flexibly, efficiently, and effectively acquire the conceptual foundations that are essential for a substantial understanding of corporate sustainability.

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**Lecture notes**

Presentation slides will be made available on Moodle after lectures.

**Literature**

Literature recommendations will be distributed via Moodle, and are available from the start of the course.

**Prerequisites / notice**

TEACHING FORMAT/ ATTENDANCE: The course includes several mandatory sessions that participants must attend to successfully earn credit points. It is not possible to take the class purely online.

**Competencies**

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<th>Lecturers</th>
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<td><strong>Abstract</strong></td>
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**Objective**

- assess the limits and the potential of corporate sustainability for sustainable development
- develop competencies that are useful in the context of corporate sustainability and beyond (analytical competency, critical thinking, problem solving)
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<td>W+</td>
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<td><strong>Abstract</strong></td>
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<tr>
<td>This course provides an overview on essential perspectives of marketing and how marketing adds value to a business. It will teach concepts, frameworks and methods for marketing decision making. The course will also look at issues related to marketing implementation. Thereby, a particular focus will be on how data and data analytics can help to support marketers in their decision making.</td>
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**Objective**

After taking the class, students will be able to

1) Understand how marketing adds value to a business.
2) Provide an overview of key concepts in marketing that are applicable to any business.
3) Understand how consumers behave and how this impacts marketing.
4) Learn how analytics and quantitative methods can help to improve decision making in marketing.
5) Get to know the elements that shape a firm’s marketing strategy (segmentation, targeting, positioning) and marketing tactics (product, price, promotion, place)

**Content**

The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their customers. It will teach concepts, frameworks and methods for marketing decision making. Specifically, the course is aims to provide students with a) an overview on the role of marketing within a business, b) details on strategic marketing management decisions and tools, c) a profound knowledge on the individual elements of the marketing mix (product, price, promotion, place), d) an awareness of specific contexts of marketing, and e) first-hand experience on data-driven techniques to support marketers' decision making.

Thus, this course will introduce key analytical tools to help solving respective managerial tasks. This is a lecture with integrated exercises. Access to a laptop is required for the exercises. The class might be thought in an in-person, remote or in a hybrid format. Students might also be taught via pre-recorded videos and assigned material for self-study.

**Literature**


The course might comprise mandatory and supplemental reading material. Other literature may be assigned in class.
Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Negotiation: fostered

Personal Competencies

- Adaptable and Flexible: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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363-0392-00L Strategic Management W+ 3 credits 2G A.-K. Weiser, C. H. Park

Abstract

This course introduces central theories, frameworks, and tools for developing competitive strategies.

Objective

The Strategic Management course aims to impart relevant competencies in strategic management, both for professional and academic development. This course offers an introduction to the fundamentals of strategy and the most widely used concepts and methods in strategic management. The course is delivered through a combination of lectures on concepts and methods, as well as case studies where students work on solving strategic issues of the case companies. The course participants will also have the opportunity to engage with firm executives, gaining insights into the real-time strategic challenges that organizations encounter, thereby acquiring practical experience.

Content

- 23.09.2024: Entering the field and course logistics
- 30.09.2024: Industry dynamics I: Industry analysis + Guest Lecture 1
- 14.10.2024: The resource-based theory of the firm + Cases
- 28.10.2024: The knowledge-based theory of the firm + Cases
- 11.11.2024: Industry dynamics II: Analysis of technology and innovation + Cases
- 25.11.2024: Wrap-up + Cases + Guest Lecture 2

The Strategic Management course delivers a comprehensive learning experience by integrating lectures on fundamental theories and concepts with practical case studies. This approach allows course participants to develop a deep understanding of essential and contemporary issues in the field, while providing opportunities for the practical application of these theoretical insights to strategic challenges faced by businesses.

The course focuses on competitive strategy, which involves analyzing and establishing a firm's position within an industry to ensure its performance. This is achieved through exploring topics such as industry structure, industry evolution, and the analysis of a firm's resources and knowledge, as well as innovation.

To succeed in the course, course participants are expected to read and understand the required readings, which consist of publications covering the most important research in management and strategy.

To emphasize the relevance of Strategic Management in real-world situations, senior executives of Swiss companies will hold guest lectures to provide their insights on strategy in practice and current topics in the field.

Number of participants is limited to 80. Registration through myStudies (first come, first served). Since some people deregister at the start of the semester, it makes sense to stay on the waiting list until after the semester start.

For further questions and if you are unable to sign up through myStudies, please contact the course assistant: http://www.smi.ethz.ch/education/strategic-management.html

For participants of the MAS-MTEC program we offer a complementary course Practicing Strategy in which students will apply the concepts of Strategic Management to their real-life contexts and organizations. Please register simultaneously for both courses if you want to take part in this course.

For more information please see: http://www.smi.ethz.ch/education/practicing-strategy.html

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363-0389-00L Technology and Innovation Management W+ 3 credits 2G S. Brusoni, A. Zeijen
System theory sees the economy as a complex adaptive system. Organizations and people are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small. How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

This course focuses on the sources of innovation (with a specific focus on digital technologies), the tools and techniques that organizations deploy to innovate routinely, and the strategic implications of technical change at different levels of analysis: individuals, firms and whole ecosystems.

This course intends to enable all students to:

- Acquire and understand the basic jargon, concepts and methods necessary to discuss, in a precise and concise manner, innovation processes and their outcomes at different levels of analysis

- Analyze the differences between individual and organizational decision processes and their innovative outcomes

- Evaluate critically the potential of different (digital) technologies to impact business organizations.

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The economic environment of today’s companies is characterized by high cost pressure, declining margins, intensified international competition, rising customer requirements and increasingly strict regulations. Strategic and operational decisions at all management levels are becoming more and more complex due to the increasing amount of data, interrelationships, conditions and target criteria to be considered. Often it is no longer possible to solve operational tasks with experience and common sense alone and to adequately estimate the consequences of decisions without software support.

Quantitative methods and models of operations research and operations management offer decision support for complex problems. Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analysed and optimized using suitable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:
- Introduction to system modelling and operations research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

Lecture notes: A printed script will be made available.

Literature: Any standard textbook in Operations Research is a useful complement to the course.

Prerequisites / notice: Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.

### Elective Courses

#### Economic Dynamics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-1137-00L</td>
<td><strong>Applied Econometrics in Environmental and Energy Economics</strong></td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>S. Tillmanns</td>
</tr>
</tbody>
</table>

*Does not take place this semester.*

*It is highly recommended to take 363-0570-00L Principles of Econometrics first.*
Abstract
The course introduces to the most common empirical methods for the analysis of issues in environmental, energy, and resource economics. The course includes computer laboratory sessions, and covers the following broad topics: demand models, discrete choice models, empirical methods in policy evaluation, field- and quasi-experiments.

Objective
At the end of the course, the students will be able to: understand the most common empirical methodologies used in environmental, energy, and resource economics; understand the problems the methodologies learnt in class aim to address; appreciate the importance of causal inference in empirical economics; read and understand the research papers in the literature; apply the empirical methods learnt in class using the software R.

Content
The course introduces students to empirical statistical methods that have wide application in environmental, energy, and resource economics and it is divided in four blocks. The first block is a quick review of the basic econometric methodology and concepts (OLS, standard errors, logit/probit models); the second block introduces demand models like the Almost Ideal Demand System, discrete choice models, and their evolutions; the third block explores causal inference in empirical economics and the main reduced-form econometric techniques used in policy evaluation, such as difference-in-differences, regression discontinuity and synthetic control; the fourth block introduces field experiments and instrumental variables, and their characteristics.

At the end of each block there will be a computer laboratory class in which the student will learn to apply the methodologies learnt in class using the statistical open-source software R. Throughout the course, students will have the chance to work on actual data used for analysis in economics papers. The lectures will make use of current research papers in the literature to illustrate practical examples in which the methodologies learnt in class have been used. Students will be expected to read in advance the paper that will be explained during the lecture.

The evaluation policy has the aim to allow students to get practical experience on the econometric methodologies learnt in class. Thus, beyond a final open-book computer exercise exam (60% of the grade), the course includes short takehome computer exercises (40% of the grade).

As the course will be centered on econometric methods, it is recommended that students have taken 363-0570-00L Principles of Econometrics first, or have otherwise a solid knowledge of basic econometric methodologies as detailed in Part 1 of Wooldridge, Jeffrey M. (2018) Introductory Econometrics : A Modern Approach. Seventh ed. ISBN: 978-1-337-55886-0. Knowledge of statistical software R is helpful, but not required and will be taught in the computer laboratory sessions.

Prerequisites / notice
It is highly recommended to take 363-0570-00L Principles of Econometrics first.
Multinational firms have grown in importance in recent decades. Given that their affiliates are located in different countries, they face

Subject-specific Competencies

Intermediate Econometrics

W

4 credits

Analytical Competencies

S. Stefanova

Concepts and Theories

363-1037-00L

Fiscal Competition and Multinational Firms

3 credits

2V

M. Köthenbürger

Method-specific Competencies

Social Competencies

Method-specific Competencies

Personal Competencies

Analytical Competencies

Communication

Creative Thinking

Critical Thinking

363-0585-00L

Intermediate Econometrics

W

3 credits

2V

S. Stefanova

Concepts and Theories

assessed

Decision-making

assessed

fostered

fostered

fostered

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The lectures will consist of both theoretical and practical components. In the theoretical part, we will discuss each estimation approach in detail. The lecture will present the assumptions, derivations, as well as the advantages and disadvantages of the estimation approach.

In the empirical part, we will look at simulation results using artificial data. Furthermore, we will investigate a particular research question using STATA.

The course will tentatively cover the following subjects:
- review of ordinary least squares (OLS) estimation
- instrumental variable estimation and two-stage least squares estimation
- seemingly unrelated regression models
- simultaneous equation models
- maximum likelihood estimation
- binary response models
- count data models
- censored and truncated regression models
- sample selection models
- treatment effect models
- static linear panel data models (random effects and fixed effects estimation)

Lecture notes
For the theoretical portions of the lectures, we will prepare slides for in-class discussion. The format of the course is in-person. Slides will be distributed electronically before each lecture.

For the applied portion of the lectures, we will provide STATA do files, log files, and data sets.

Problem sets will also be made available after every lecture. These problem sets will not be collected or graded, but students can use them in order to prepare for the final exam. Solutions will be made available in the following lecture.

While there is no required textbook for the course, we draw from the following texts, which are also recommend for the preparation of the exam:
- Cameron, A.C. and Trivedi (2009). Microeconometrics Using Stata.

Literature

Prerequisites / notice
Prior basic knowledge of matrix algebra and probability theory is strongly recommended.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Problem-solving
Social Competencies
- Communication
- Cooperation and Teamwork
Personal Competencies
- Critical Thinking
- Integrity and Work Ethics

363-1159-00L Labor Economics W 3 credits M. Siegenthaler, D. Kopp

Abstract
The lecture provides an introduction to central issues in labor economics, including the determinants of labor supply, firms' demand for workers, minimum wages, unemployment, wage inequality, the effects of digital technologies on the labor market, and labor market discrimination. It presents research papers on these issues and discusses the empirical challenges related to their research designs.

Objective
After taking this course, students will be able to
- analyze the behavior of actors in the labor market within the conceptual framework of economic theory.
- explain phenomena such as unemployment, wage inequality, labor market discrimination, and labor market imperfections.
- understand how digital technologies such as generative artificial intelligence affect the labor market.
- comment on policy-relevant issues such as minimum wages, a universal basic income, and unemployment insurance.
- comprehend and present the results of the relevant empirical studies on these issues.
- understand the challenges associated with a causal identification of research questions in labor market research.

Content
In this course, students will get answers to a range of relevant questions about modern labor markets: Who works, how much, and why? Do people work less if they have a universal (guaranteed) income or pay higher taxes? How does a minimum wage reduce the employment of workers it intends to help? How does unemployment arise? Did technological change (e.g., computers and robots) contribute to the rise in wage inequality in developed countries? How does generative artificial intelligence (AI) affect the labor market? Is there wage and hiring discrimination against women, men, and foreigners in the labor market, and if so, why? After presenting how modern labor economics conceptualizes these issues, the course discusses state-of-the-art empirical research papers that answer these questions. In this context, the course familiarizes students with modern data science methods that researchers apply to get causal answers to research questions. This introduction to modern applied economics does not require any prior background in economics or statistics.

The course targets students interested in the functioning of labor markets and the academic debate about specific labor market policies. A second target group is students that want to learn how modern empirical research in labor economics uses big data to analyze central issues in labor economics.

The performance will be assessed based on a written exam at the end of the semester.

Competencies
Subject-specific Competencies
- Concepts and Theories
Method-specific Competencies
- Analytical Competencies
Social Competencies
- Communication
Personal Competencies
- Critical Thinking

363-1021-00L Monetary Policy W 3 credits J.-E. Sturm, A. Rathke

Abstract
The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the differences between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real world issues.

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For the functioning of today's economy, central banks and their policies play an important role. Monetary policy is the policy adopted by the monetary authority of a country, the central bank. The central bank controls either the interest rate payable on very short-term borrowing or the money supply, often targeting inflation or the interest rate to ensure price stability and general trust in the currency. This monetary policy course looks into today's major questions related to policies of central banks. It provides insights into the monetary policy process using core economic principles and real-world examples.

**Objective**

This lecture will introduce the fundamentals of monetary economics and explain the working and impact of monetary policy. The main aim of this course is to describe and analyze the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy, the effectiveness of monetary policy actions, the differences between monetary policy rules and discretionary policy, as well as in institutional issues concerning central banks, transparency of monetary authorities and monetary policy in a monetary union framework. Moreover, we discuss the implementation of monetary policy in practice and the design of optimal policy.

**Content**

The course will be based on chapters of:

We cover the three most important models of monetary theory that are used for the conduct of monetary policy. The models are covered from both a theoretical perspective - in terms of the model and their intuition - and a practical perspective, in terms of how the models can be solved numerically and how they can be used to understand monetary-policy issues.

**Lecture notes**

The course Moodle page contains announcements, course information and lecture slides.

**Literature**

The course will be based on chapters of:

Prerequisites / notice

Basic knowledge in international economics and a good background in macroeconomics.

**Competencies**

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<td>Self-presentation and Social Influence</td>
<td>Self-awareness and Self-reflection</td>
</tr>
</tbody>
</table>

**363-1177-00L**

**Monetary Theory**

W 3 credits 2G  H. J. van Buggenum

**Abstract**

We cover the three most important models of monetary theory that are used for the conduct of monetary policy. The models are covered from both a theoretical perspective - in terms of the model and their intuition - and a practical perspective, in terms of how the models can be solved numerically and how they can be used to understand monetary-policy issues.

**Objective**

After taking this course, students will be able to:
- Understand why intrinsically useless assets such as banknotes have value, i.e., understand the role of assets (money in particular) as a means of payment.
- Understand why nominal assets can be of real importance, i.e., understand the role of money as a unit of account.
- Understand inflation and interest-rate dynamics, and how these relate to real economic activity and expectations.
- Understand and apply models that are used for the conduct of monetary policy.
- Solve dynamic macro models with a computer, for instance with Python, Matlab and Dynare.
- Apply the theory to some empirically relevant issues for monetary policy, including: the 2008-2009 financial crisis; the zero-lower bound on nominal interest rates; and large supply and demand shocks.
- They will learn how to relate monetary theory to empirically relevant and topical issues, such as unconventional monetary policy (quantitative easing), high inflation, the zero lower bound on nominal interest rates, and financial crises.

**Content**

The course is aimed at students who:
- are interested in economics in general and monetary economics in specific;
- are interested in how mathematical models can be used to capture real-world phenomena, particularly those related to money, inflation, and interest rates.
- command over good mathematical skills;
- command over good knowledge of microeconomics and macroeconomics, for instance from core courses in the Master program;

Students who fulfil these requirements will benefit from the course in the following dimensions:
- they will gain a deeper understanding of phenomena related to money, interest-rates and inflation, which are key elements to understand how real-world economies operate;
- they will be able to understand models that are used by researchers and central banks to study and design monetary policy;
- they will gain an understanding of how these models can be solved and simulated with a computer;
- they will learn how to relate monetary theory to empirically relevant and topical issues, such as unconventional monetary policy (quantitative easing), high inflation, the zero lower bound on nominal interest rates, and financial crises.

The course consists of weekly meetings that take the form of lectures and tutorials. The provisional agenda is as follows:

**Week 1-2:** Cash-in-advance model; a model with a transactional role for money.
- Session 1: Lecture
- Session 2: Tutorial

**Week 3-6:** New-Keynesian model; the workhorse framework for monetary policy.
- Session 3: Lecture; the benchmark 3-equation model.
- Session 4: Tutorial; solving the model with the computer.
- Session 5: Lecture; monetary policy and the zero-lower bound.
- Session 6: Tutorial; monetary policy and the zero-lower bound.

**Week 6-10:** New-Monetarist model; a model with a role for assets as means of payment.
- Session 7: Lecture; the benchmark model.
- Session 8: Tutorial; self-fulfilling inflation dynamics.
- Session 9: Lecture; a model of monetary policy in the interbank market.
- Session 10: Tutorial; stabilization policy in the interbank market.
- New-Keynesian model: Introduction to monetary policy, inflation, and the business cycle (Gali)  

| Competencies | Subject-specific Competencies | Concepts and Theories | fostered |
| - | Techniques and Technologies | fostered |
| Method-specific Competencies | Analytical Competencies | fostered |

| 363-1178-00L | Population Ageing and Pension Economics | W | 3 credits | 2V | C. Wan |

**Abstract**
Population ageing puts pressure on the sustainability of public insurance systems and increases the individual responsibility for retirement security. This course provides an overview of the economics of ageing and focuses on pensions and retirement decisions. It introduces participants the state-of-art knowledge, theories, and econometric methods to conduct research in the related areas.

**Objective**
The course aims to provide an understanding of the economics of ageing, with a focus on pensions and retirement. After completing the course, participants will be able to:

- Understand the basic economic aspects related to demography, social insurance and retirement.
- Describe the ongoing demographic transitions in developed and developing countries.
- Understand the basic structure of pension systems.
- Discuss the risks and merits of different pension systems and reform options.
- Understand the typical research designs and methods for policy evaluation relevant to retirement.
- Understand the theoretical framework to analyse individual consumption and savings behaviours over their life cycle.
- Understand key behaviour issues relevant to retirement decisions.
- Identify research questions related to population ageing.

**Content**
The course introduces students to the economics of population ageing with a focus on pensions and individual retirement behaviour. The course has three parts.

The first part provides an overview of the causes and economic consequences of population ageing. Topics include:
- Measurements of ageing, and current situations of population ageing around the world.
- Mortality, fertility, and their determinants.
- Mortality compression, healthy life expectancy, health costs, and gender gap.
- Design of pension, health, and long-term care insurance systems.

The second part discusses pension systems and relevant policies. Topics include:
- Impact of pension and retirement policies on the labour market, health, long-term care, wealth and savings.
- Pension reform options and their consequences.
- Gender inequality and inter-generational fairness.
- Financial risks in pension funds and variable annuities.

The third part of the course focuses on household financial planning for retirement. Topics include:
- Empirical evidence about consumption and savings in retirement.
- Retirement savings puzzle, annuity puzzle, and demand for long-term care insurance.
- The life-cycle framework to analyse how individuals should plan for their savings, investment, insurance, and other retirement-related decisions.
- Behaviour issues that could affect retirement-related decisions, such as inertia and default, peer effect, framing, hyperbolic discounting, mental accounting, and loss aversion.
- Role of financial literacy.
- Typical experimental designs and econometric methods to examine issues in retirement planning.


| Competencies | Subject-specific Competencies | Concepts and Theories | assessed |
| - | Techniques and Technologies | assessed |
| Method-specific Competencies | Analytical Competencies | assessed |
| Media and Digital Technologies | fostered |
| Problem-solving | assessed |

**Competencies**

| Social Competencies | Communication | assessed |
| Cooperation and Teamwork | fostered |
| Leadership and Responsibility | fostered |
| Sensitivity to Diversity | fostered |

| Personal Competencies | Creative Thinking | fostered |
| Critical Thinking | fostered |
| Integrity and Work Ethics | assessed |
| Self-awareness and Self-reflection | fostered |
| Self-direction and Self-management | fostered |

| 363-1161-00L | Time Series Econometrics and Macroeconomic Forecasting | W | 3 credits | 2V | S. Sarfaraz |

**Abstract**
This course introduces the methods for analyzing and forecasting macroeconomic activity using multivariate time series analysis. We will study econometric models that central banks, government agencies and other research institutions use to analyze and forecasts macroeconomic variables.

**Objective**
How will the overall economy develop during the next quarters and years? What is the impact of the exchange rate on economic activity and inflation? How should we derive macroeconomic scenarios under alternative assumptions about the evolution of key variables like oil prices, exchange rates or the world economic activity? What are the effects of changes in monetary policy, fiscal policy or COVID-19 on economic activity? After completing this course, students will be able to tackle these and related questions using multivariate time series methods as applied by researchers and professional forecasters.
The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and

3 credits

fostered

3 credits

fostered

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban

Concepts and Theories

Methodological Foundations of Economics

assessed

Course slides will be made available to students prior to each class.

W

3 credits

2G

M. Köthenbürger, G. Loumeau

Urban Systems and Transportation

This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and

highlight how transport infrastructure investments can affect the location, size and composition of such systems.

Competencies

Objectives:

Subject-specific Competencies

Method-specific Competencies

Social Competencies

Personal Competencies

assessed

assessed

assessed

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The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong microfoundations and allow for precise policy recommendations.

Lecture notes

Course slides will be made available to students prior to each class.

Literature

Course slides will be made available to students.

Competencies

Principles of Macroeconomics

Principles of Econometrics

363-1047-00L

363-1180-00L

Methodological Foundations of Economics

have learned how to critically assess academic knowledge on concrete questions. A large share of the course will be devoted to case

studies.

1.

2.

3.

4.

studies.

identifying core assumptions in economic research papers and assess the scope of their results. Forming an opinion on an applied economic topic based on academic work with the right critical distance.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1592 of 2667
Economic models rely on assumptions which are wrong. In economics, theoretical but also empirical studies often contradict each other, even among the most celebrated contributions. Behind its methods borrowed to natural sciences, economics rely on strong postulates and on different schools of thought. How should we handle contradictions, idealizing hypotheses or results too good to be true? What do we actually learn about the social world through economic research?

In this course, we will face those questions from both a theoretical and a practical perspective.

On the theoretical side, our approach will be an epistemological one. We will reflect on the methodological foundations of economics and the type of knowledge it aims to produce. We will dig into some of its most central concepts: the quest for causality, equilibrium reasonings, and the revealed preferences approach. While conceptual, our journey will take us through the formal foundations of econometrics, decision theory, and game theory.

On the practical side, the aim is to equip students with the necessary tools to effectively navigate existing economic research to obtain answers to real-world questions. After this course students will be able to form a critical opinion on topical matters, such as “should public debt be canceled in developing countries?” or “are the Paris agreements good news for the climate?”, without being experts on these questions.

Overall this course can be seen as an epistemological introduction to economics as well as methodological training for using academic knowledge in real life. It is thus intended for a general audience interested in economics, without specific previous training needed.

Lectures will be structured around a theoretical introduction and a paper’s discussion by the teacher, followed by a group discussion on other papers. Students are expected to prepare this discussion in groups and will be graded according to their participation. An additional evaluation will take place through a final exam.

### Literature

- Game theory and economic modeling, (1990) David Kreps
- A model of competing narratives, (2020) Kfir Eliaz and Ran Spiegler
- A Course in Game Theory, (1994) Osborne and Rubinstein
- Economic Theory; Economics, Methods and Methodology, (2021) Gilboa, I., A. Postlewaite, L. Samuelson, and D. Schmeidler
- Between Mathematical Formalism, Normative Choice Rules, and the Behavioural Sciences: The Emergence of Rational Choice Theories in the late 1940s and early 1950s, (2017) Catherine Herfeld

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### 363-1107-00L Youth Labor Market Outcomes, Institutions and Governance of Education and Training Systems

**Abstract**

Finding and retaining talent for companies is becoming increasingly important nowadays. While Switzerland has a comparatively efficient labor-market-oriented education system, other countries find it more challenging to develop the skills needed by the labor market. We will consider contributions of economics and other social sciences to understanding outcomes of education and training systems.

**Objective**

Using internationally comparable data, students can measure, compare and assess the human capital performance of education systems.

Students can use case studies to identify and evaluate different institutional features of labor-market-oriented education systems, and use those features to explain certain outcome effects on the youth labor market.

Students are able to deduce the consequences of countries’ different initial institutional situations, to locate them culturally, and to point out problem-solving measures from the perspective of a company seeking improved skills preparation.

In the context of digitalization and rapid technological change, finding and retaining talent for companies is becoming increasingly important. While Switzerland has a comparatively efficient labor-market-oriented education system, other countries find it much more challenging to develop the skills needed by the labor market. Without strong education and training systems, it is difficult to secure the volume of labor, quantitatively and qualitatively, that is necessary for prosperity and social development. We will also investigate incentives of firms to train, and the integral role that AI will have in the context of vocational education and training.

The course will take a macro perspective to show how we can measure the performance of different education and training systems. It will also describe the institutional challenges countries face when companies complain that a shortage of skilled professionals is limiting growth. We will consider the contributions of economics and other social sciences to understanding the performance of diverse education and training systems, which we regard as both as economic and institutional phenomena.

### Competencies

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### 363-1192-00L Economics, Politics, and Markets
Understanding a society’s economic, social, and market outcomes requires one to understand its politics. Yet, a common view is that politics is unpredictable and unintelligible--in this course, we push against this view. We will use game-theoretic tools from economics to analyze politics in a structured and principled way and to develop new insights into policy making and regulatory decisions.

The objective of this course is to introduce students to the formal analysis of politics, via economic models.

After completing this course:
- Students will be able to analyze economic models of politics and interpret the results.
- Students will be able to evaluate economic models of politics
- Students will be able to interpret real-world political phenomena in terms of economic models
- Students will be able to develop and create new insights for politics using economic models

This course will introduce students to a variety of foundational economic models of politics and policy making. This includes–but is not limited to–models of electoral competition, political agency, legislative bargaining, and the interaction between political and market outcomes (e.g., via market and business regulations).

The course material will mainly be theoretical and mathematical (primarily using game theory). Real-world examples and empirical research will be discussed to help motivate and evaluate the theoretical material. Most of the content will focus on the United States, for which rich theoretical and empirical literatures exist. However, the key tools, ideas, and insights can be applied more generally and beyond the United States.

The course assumes basic mathematical competencies (e.g., familiarity with algebra, multi-variable calculus, and probability). We will not assume prior knowledge of game theory--the course will introduce game theoretic concept as they are required. However, having previously taken an introductory course in game theory will be an advantage (e.g., D-MTEC courses such as: 363-0558-00L “Introduction to Game Theory: Strategic and Cooperative Thinking” or the recent edition of 363-0515-00L “Decisions, Markets, and Games”).

There are no formal admission requirements. It is expected that students have a basic level of mathematical competence. It will be beneficial if students have taken an undergraduate level course in microeconomics or game theory.

### Literature
The course material primarily draws from the following textbook:

### Competencies
#### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

#### Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

#### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Prerequisites / Notice
There are no formal admission requirements. It is expected that students have a basic level of mathematical competence. It will be beneficial if students have taken an undergraduate level course in microeconomics or game theory.

### Finance and Investment

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>363-1081-00L</td>
<td>Asset Liability Management and Treasury Risks</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Mangold, M. Eichhorn</td>
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Asset Liability Management (ALM) is key to the financial success of any corporation. The goal is to develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and related profits and losses, including identification and mitigation of undue risks taken. This course is geared towards preparing students to apply these concepts in practical settings.

The main learning objectives of this course are:
- develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and their respective contribution to profits and losses
- measure and assess exposures to risk factors such as interest and FX rates, equity and commodity prices, as well as liquidity events
- trading and hedging to mitigate undue risks incurred

The course is organized around a series of case studies. We will first discuss and develop an understanding of the fundamentals on different aspects of the management and risk management of the balance sheet. Using real life case studies each concept will then be directly applied and tested. In-class discussions, presentations and one written assignment are used to facilitate active and interactive learning in a stimulating environment. During the case studies students will frequently work in small groups. Therefore, the number of participants is limited to 40.

The course focuses on the application of finance concepts to the financial management of corporations and is geared towards preparing students to apply these concepts in practical settings. Executives of all sectors are expected to have a sound understanding of the content covered. As such, the course is not exclusively targeted at students who are considering a career in the financial services sector. It also recommended for students who want to work in the finance, treasury or risk area of corporates. It is also suitable for students who want to work for a consultancy firm.
New Technologies in Finance and Insurance

Assessed

Participants should have a basic understanding of financial management, gained, for example, from prior undergraduate economics, business, or accounting studies.

Prerequisites

New Technologies in Finance and Insurance

Assessed

No single textbook covers the course, below we list some useful references. Further materials will be made available to students prior to the lectures.


Methods

For the exam, only the material provided will be relevant.

Methods

Corporate Finance

3 credits

W

2G

A. Kind

Corporate Finance

W 3 credits 2G A. Kind

Corporate Finance is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

Objective

Upon successful conclusion of the course, students will...

1) know what corporate finance and corporate governance are about;
2) be able to price a wide array of corporate securities, assets, and projects, e.g., stocks, bonds, and options;
3) master three valuation approaches (discounted cash-flow valuation, relative valuation, and real-options valuation) and know about their applicability, their strengths, and their weaknesses;
4) know how to finance firms at different stages of their lifecycle;
5) be familiar with terms, acronyms, and concepts in the world of finance;
6) know how to relate real-world corporate events (past and current) to concepts learnt in class;
7) have increased their appeal as future manager, employee or entrepreneur by relevant knowledge in the field of finance in general and corporate finance in particular.

Content

"Corporate Finance" is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

In the following, for each of the three parts of the course, key aspects, are listed.

Part I: Corporate Finance and Corporate Governance

- Corporations and their characteristics (e.g., centralized management, limited liability, free transferability of economic claims, legal personality)
- Corporate finance and its goals (e.g., shareholder-value approach vs. stakeholder-value approach)
- Corporate governance problems and possible solutions (e.g., over-investment, under-investment, self-dealing, monetary incentives, board of directors, the market of corporate control, leverage, product-market competition)

Part II: Investment Decisions/Valuation

- Discounting and compounding
- Present value tools (e.g., perpetuities, growing perpetuities, annuities, growing annuities)
- Bond pricing and interest rates (e.g., types of bonds, term structure of interest rates, yield-to-maturity, duration concepts, forward rates, "riding the yield curve")
- Risk and return (e.g., moments of stock returns, modern portfolio theory, capital market line, systematic risk vs. unsystematic risk)
- CAPM in practice (e.g., computation of the risk free interest rate, beta, and the market risk premium; security market line)
- DCF Analysis: Cost of capital and cash flow estimation
- Relative valuation (e.g., earnings multiples, book multiples, sales multiples, fundamental drivers of multiples)
- Real options (e.g., option to abandon, option to delay, option to expand)

Part III: Financial Policy

- Corporate financing (e.g., instruments, internal vs. external financing, equity financing vs. debt financing, crowdfunding, M&M and beyond)
- Payout policy (e.g., dividends, par value reductions, share buybacks, M&M and beyond)

Lecture notes

Slides in English (and any other relevant material) will be available for download on the following website: https://moodle-app2.let.ethz.ch/course/view.php?id=4479

Literature

For the exam, only the material provided will be relevant. However, interested students may refer to the following textbook for an alternative, or a complementary, reading:


New Technologies in Finance and Insurance

Assessed

Technological advances, digitization and the ability to store and process vast amounts of data has changed the landscape of financial services in recent years. This course will unpack these innovations and technologies underlying these transformations and will reflect on the impacts on the financial markets.

Abstract

New Technologies in Finance and Insurance

Does not take place this semester.

New Technologies in Finance and Insurance

Assessed

No single textbook covers the course, below we list some useful references. Further materials will be made available to students prior to the lectures.


Methods

For the exam, only the material provided will be relevant.

Methods

Abstract

New Technologies in Finance and Insurance

Does not take place this semester.
Objective

After taking this course, students will be able to:
- Understand the fundamentals of emerging technologies like supervised learning, unsupervised learning, reinforcement learning or quantum computing.
- Understand recent technological developments in financial services and how they drive transformation, e.g. see applications from fraud detection, credit risk assessment, portfolio optimization.
- Reflect about the challenges of implementing machine learning in finance, e.g. data quality and availability, regulatory compliance, model interpretability and transparency, cybersecurity risks.
- Understand the importance of continued research and development in machine learning in finance.

Content

Overall, emerging technologies are transforming the finance and insurance industries by improving efficiency, reducing costs, enhancing customer experiences, and facilitating innovation. Hence, the financial manager of the future is commanding a wide set of skills ranging from a profound understanding of technological advances and a sensible understanding of the impact on workflows and business models.

Students with an interest in finance, banking, and insurance are invited to take the course without explicit theoretical knowledge in financial economics. As the course will cover topics like machine learning, cyber security, quantum computing, an understanding of these technologies is welcomed, however not mandatory.

The course will also go beyond technological advances and will also cover management-related contents. Invited guest speakers will contribute to the sessions. In addition, separate networking sessions will provide entry opportunities into finance and banking. Selected guest speakers will cover different application from the field of finance and insurance, e.g.:
- Fraud detection: Machine learning algorithms can be trained to identify unusual patterns in financial transactions, helping to detect fraudulent activities.
- Credit scoring: Machine learning can be used to develop more accurate credit scoring models, taking into account a wider range of data points than traditional models.
- Investment: Machine learning can be used to analyze market trends, identify potential investment opportunities, and develop predictive models for asset prices.
- Risk management: Machine learning can be used to model and forecast risk, helping financial institutions to manage and mitigate risk more effectively.

The course is divided in sections, each covering different areas and technologies. Students are asked to solve a short in-class exam and one out of two group exercises cases.

Competencies

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Human and Entrepreneurial Behaviour

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<tr>
<td>363-1082-00L</td>
<td>Enabling Entrepreneurship: From Science to Startup</td>
<td>W</td>
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Students should provide a brief overview (unto 1 page) of their business idea that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

Abstract

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective

Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs.
2. The students can be from business or science & technology.
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea.
The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startups
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders' agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

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### Contents

**Psychological Aspects of Risk Management and Technology**

Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are treated. Three components of risk management (risk identification/evaluation, risk mitigation, risk communication) and underlying psychological and organizational processes are discussed, using company case studies to promote in-depth understanding.

- You know how risk and risk management is defined and applied in different industries
- You know the challenges of decision making under risk and uncertainty and its effects on organisations
- You know about and (partially) apply some risk management tools
- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

This course consists of three main elements:

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).
Content

The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication

- Psychological and organizational concepts relevant in risk management
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

- Group projects related to company case studies

Lecture notes

There is no script, but slides will be made available before the lectures.

Literature

There are texts for each of the course topics made available before the lectures.

Prerequisites / notice

The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

Competencies

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363-0790-00L Technology Entrepreneurship W 2 credits 2V F. Hacklin

Abstract

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding. This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

Objective

This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Content

Weekly sessions - recorded.
10+ sessions carried out by guest lecturers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...). Final session: multiple choice semester assignment (100% of grade).

Typical lecture format (2h):
15': Introduction
60': Guest testimonial
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Lecture notes

Lecture slides and case material

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363-0301-00L Work Design and Organizational Change W 3 credits 2G G. Grote

Abstract

Good work design is crucial for individual and company effectiveness and a core element to be considered in organizational change. Meaning of work, organization-technology interaction, and uncertainty management are discussed with respect to work design and sustainable organizational change. As course project, students learn and apply a method for analyzing and designing work in business settings.

Objective

- Know effects of work design on competence, motivation, and well-being
- Understand links between design of individual jobs and work processes
- Know basic processes involved in systematic organizational change
- Understand the interaction between organization and technology and its impact on organizational change
- Understand relevance of work design for company performance and strategy
- Know and apply methods for analyzing and designing work
The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterium
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

A list of required readings will be provided at the beginning of the course.

The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.

The course consists of two parts. Part I provides an introduction into important topics in the field of the economics of innovation. Part II consists of empirical exercises based on various firm-level data sets, e.g., the KOF Innovation data, data about the digitization of firms, data about environmentally friendly innovations, or patent data. In part I, we will learn about ...

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Does not take place this semester.

Abstract
The course focuses on important factors that drive the innovation performance of firms, like innovation capabilities, the use of digital technologies, environmental and innovation policy and it shows how innovation activities relate to firm performance and to the technological dynamics of industries. We also discuss the implications of the findings for effective economic policy-making.

Objective
The course provides students with the basic skills to understand and assess empirically the technological activities of firms and the technological dynamics of industries. In addition, the aim is to promote the understanding of the essential criteria for innovation policy-making.

Personal and social skills are also addressed during the course. In particular, there is the possibility to improve communication and presentation skills, the ability to develop arguments for the positions of political representatives, policy-makers, pressure groups, or NGOs in connection with innovation policy-making.

Content
The course consists of two parts. Part I provides an introduction into important topics in the field of the economics of innovation. Part II consists of empirical exercises based on various firm-level data sets, e.g., the KOF Innovation data, data about the digitization of firms, data about environmentally friendly innovations, or patent data. In part I, we will learn about ...

Lecture notes
Will be provided in the course and in the e-learning environment: https://moodle-app2.let.ethz.ch/course/view.php?id=15120

Literature
Literature will be presented in the course. For an introduction into the economics of innovation see G.M. Peter Swann, The Economics of Innovation - an Introduction, Edward Elgar, 2009.


Prerequisites / notice
Course is directed to advanced Master-Students and PhD Students with an interest in empirical studies.
**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed

---

**The Economics of Climate Change**

**W 3 credits 2G A. Goussebaïle**

**Abstract**
After an introduction to the issue of climate change, we will see the policy instruments that can be used to mitigate it. We will then discuss the optimal level of these policies. Finally, we will analyze the political constraints that limit their implementation.

**Objective**
Students will acquire a general understanding of the problem faced by the society with climate change, as well as the ways and the obstacles to deal with it. From a technical point of view, this course intends to teach participants the main tools used in economic sciences to discuss the problem of climate change, understand its key determinants, advise policy makers and understand the constraints of the latter.

**Content**
The introductory part will explain why climate change represents a main issue for our societies. We will see the anthropogenic causes (i.e. greenhouse gas (GHG) emissions), the physical mechanism and the economic consequences of climate change. Then, we will introduce economic science modeling with the notion of externality to explain the excessive GHG emissions and characterize the societal challenge raised by climate change.

The second part of the course will present the different policy instruments for reducing GHG emissions (emission taxes, abatement subsidies, cap-and-trade system, standards). We will compare their performance and their distributional effects with regard to several aspects, with a special focus on the impact of uncertainty.

The third part of the course will focus on the level at which climate policies should be implemented, which depends on the cost of GHG emission abatement and the benefit of climate change mitigation. We will analyze the main drivers of the optimal emission abatement level, in particular discounting. We will also detail the economic models developed to evaluate the optimal abatement, namely Integrated Assessment Models.

The last part of the course will address the reasons why policy makers have only weakly implemented climate change policies up to now. We will discuss the difficulties of finding an international agreement for GHG emission reduction in a world with a large number of countries. We will also see why the time delay between GHG emissions and climate change may make society and policy makers reluctant to implement significant climate change policies.

**Lecture notes**
Lecture Notes of the course will be sent by email to officially subscribed students.

**Literature**
The main reference of the course is the set of lecture notes; students will also be encouraged to read some influential academic articles dealing with the issues under study.

**Prerequisites / notice**
Elementary knowledge of economic theory is a plus but not a prerequisite.

---

**An Introduction to Experiments in Consumer Behavior**

**W 3 credits 2G U. Bernardic**

**Abstract**
Designed for master students, this course offers insights and practical experience in behavioral economics and marketing experiments. It includes: 1) Mastering experiment design (RCT, A/B testing, conjoint analysis), programming, and implementation of experiment through focused lectures. 2) Selecting a seminal experiment, replicating it, and presenting a poster on the key findings.

**Objective**
After taking a course, students will be able to:
- design a simple (online) experiment with an open-source program, hands-on preregistration/replication
- recruit participants
- basic data analysis and analytical skills (in R)
- present (a poster) and discussion skills
- collaboratively work in groups
Content

The course is especially suitable for master students who plan to conduct empirical research for their master thesis, or students who wish to get hands-on experiences with experimental methods. The objective is to provide students with the theoretical foundations for designing, implementing, conducting, and analyzing experiments, and hands-on experiences on empirical methods in behavioral economics or marketing (consumer behavior focus). After a brief recap of the counterfactual approach to causal inference and experimental designs, the course will cover the theoretical and practical aspects of designing and conducting survey experiments. The course will be divided in two stages. In stage 1 (theoretical part), students will learn how to design, plan, program, and run an experiment by attending to lectures. In stage 2 (practical part), students will work in a group, and choose one experiment in the area of behavioral economics or marketing, conduct a replication of that experiment using the techniques acquired in stage 1, and make and present a poster on the results of the replication. Performance in both, the theoretical and the practical part contribute equally to the final grade. In more detail, 50% of the final grade will be based on regular assignments that have to be submitted online prior to class (25%), and active participation during the weekly meetings (25%). The 50% of the grade will be based on the quality of the conducted research project (experimental design, data collection, statistical analysis) and the final presentation on the last day of class. Upon completion of this course, students will be equipped with a robust set of skills. They will learn to design simple online experiments using open-source programs, emphasizing hands-on preregistration and replication methods. Students will also acquire the competence to recruit participants effectively, and hands-on experiences with basic data analysis and analytical skills, utilizing R, a powerful tool for statistical computing and graphics. Essential to the dissemination of research, students will enhance their ability to present findings and engage in scholarly discussions through poster presentations.

Furthermore, this course emphasize the importance of teamwork, preparing students to collaboratively work in groups, an essential skill in both academic and professional settings.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

➡️ Supply Chain and Information Systems

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Abstract

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

Objective

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:
- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.
The goal of the lecture is to understand the main challenges of corporate transformation and to demonstrate the application of a holistic approach to business transformation projects by introducing an integrated model dealing with three main design areas "strategy", "processes" and "information systems" and applying this model to various case studies.

**Objective**

The goal of the lecture is to understand the main challenges of corporate transformation and to demonstrate the application of a holistic project procedure model for corporate transformation projects with special emphasis on the alignment of business and IT. The student should understand and be able to explain:

- the main reasons for corporate transformation,
- the relevant management processes to manage corporate transformation,
- the interdependencies between strategy, processes and information systems, especially how this three levels interrelate,
- the critical success factors for the successful accomplishment of large scale corporate transformation projects,
- the main instruments of project, quality and change management and the different types of resulting IT projects.

**Content**

The globalization of the world leads to an increasingly faster pace in business transformation. Enterprises have to adapt faster and even faster to the environmental changes in a global economy to remain competitive and to make sure they stay in business. In today's new circumstances, the fast adaptation through large scale corporate transformation projects that change strategy, business processes and information systems is critical to ensure competitiveness for tomorrow. The introduction of new business processes and information systems typically takes years in very complex large scale projects. Many projects fail because of insufficient alignment between decision makers in business and IT. Unclear understanding of the overall project scope, undefined roles and responsibilities, unclear project processes, quality problems and resistance to change are some typical problems found in such projects. The lecture is subdivided into following modules:

- Corporate development introduction and motivation,
- Parallelization of corporate development and complexity reduction,
- Planning process and project portfolio management in corporate development,
- Management of large scale projects integration of strategy, processes and information systems,
- Quality management in large scale projects,
- Project management in large scale projects,
- Change management within projects.

The lecture is accompanied by four case studies that are used to exemplify the contents of the lecture by applying the concepts to real situations in corporate life.

**Literature**

Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
1) individual decision making under risk
2) models of insurance demand, risk sharing, insurance supply
3) information issues in insurance markets
4) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Literature
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume 1;

Further readings:

References will be given on a topic-by-topic basis during the course.

Competencies

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Technology and Innovation

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<tr>
<td>363-0861-00L</td>
<td>Alliance Advantage - Exploring the Value Creation Potential of Collaborations</td>
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Abstract
Alliances within innovation ecosystems are essential for developing new business models that address the increasing complexity of technologies and systems, as well as the intensifying global competition. Organizations are compelled to prioritize selected partnerships for value creation. We will emphasize the role of alliances and collaborations in driving innovation within these ecosystems.

Objective
Learning outcomes professional competence
The students
- learn and understand the management basics of inter-firm collaboration and organizational networks (strategy considerations incl. collaborative business models; cultural aspects including both corporate culture and international aspects, risk management, communication, etc.)
- realize the value creation potentials of alliances (added value)
- understand underlying theoretical models (mainly from the institutional economics, focusing on transaction cost and principal agent theory)
- identify and understand specific forms of collaboration (strategic alliances, joint ventures, Networks, etc.)
- apply tools hands on in real companies (planned in collaboration with companies)

Learning outcomes methodological competence
- Writing academic papers
- Developing structured documentation of interviews (in form of a presentation)
- Transferring theory directly into practical application
- Contributing to the learning journey

Learning outcomes social competence
- Improving communication skills as basics for collaboration
- Developing and applying team work skills
- Work together with industrial partners
- Coping with conflicts resolution in teams
The ever-increasing complexity of technologies and systems, coupled with heightened competitive pressure and the need to shorten time-to-market, drives organizations to concentrate on their core competencies. Collaborating with external partners presents a crucial value creation opportunity, significantly impacting daily management activities. This lecture aims to provide a comprehensive understanding of the unique management requirements for successful cooperation.

Content:
- Introduction to the theory and management of inter-firm collaboration and networks.
- Examination of the formation, management, and evolution of collaborations and networks.
- Exemplary collaborations in marketing, development, and manufacturing.
- Special forms of collaborations: innovation ecosystems, strategic alliances, joint ventures and mergers & acquisitions.

Learning Journey:
- Week 1: Introductory day providing an overview of the theoretical framework, explaining the course concept, case study(ies) and intro to the first assignment.
- Weeks 2-5: First assignment focusing on key aspects of the framework: Networked Business Strategies; Culture and People Orientation; Leadership, Interaction and Communication; Resilience, Risk and Trust; Agile Structures and Processes; Collaborative Skills Development. This assignment will build the foundational knowledge necessary for the second part of the seminar.
- Mid-Semester: Presentation of the first assignment results, supplemented with additional input using a case study, preparation for the second assignment.
- Second Assignment: Analysis of real alliance projects within partner companies, i.e. preparing and conducting an interview, summarizing the interview into a presentation.
- Final day: Best practice exchange session to conclude the course.

This structured approach ensures a thorough understanding of inter-firm collaboration management, equipping participants with the necessary skills to navigate and leverage these partnerships effectively.

Lecture notes
- Lecture slides
- Current course material
- Harvard Case Studies

Literature
A list with recommended publications will be distributed in the lecture.

Classic Books:
- HBR Collaborating Effectively ISBN 978-1-4221-6264 4
- HBR on Mergers and Acquisitions: ISBN 1-57851-555-6

Prerequisites / notice
The number of students participating in the lecture is limited to 30.

Competencies

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Cases in Technology Marketing

Number of participants limited to 20.

Students have to apply for this course by sending a CV and an one-page motivation letter until 31.8.2024 to Theresa Schachner: tschachner@ethz.ch. Additionally please enroll via myStudies. Places will be assigned on the basis of your motivation letter.

Abstract
The seminar “Cases in Technology Marketing” introduces students to key concepts and tools in technology marketing and familiarizes them subsequently with the challenges that (marketing) managers face in technology intensive markets by using real life cases.

Objective
1. Understanding and applying common business tools and frameworks
2. Understanding current challenges of managers in technology-intensive markets
3. Defining and analyzing comprehensive business problems using the example of a leading Swiss manufacturing company (Bühler AG)
4. Developing and evaluating different alternative case solutions
5. Making decisions on case solutions, justifying and defending them
6. Transferring case solutions into practice by formulating specific instructions for the management
7. Creation of novel, innovative ideas that help the company to gain a competitive edge
8. Cooperation in teams and coordination of team tasks
9. Adequate communication to and eye-level discussions with C-level managers
Large- and medium-sized corporations play a central role in the economic activity of most developed and developing countries. Many of these organizations perform multiple business activities in multiple markets. In the face of increasing international competition, globalization, technological development, deregulation, and the emergence of new markets and industries, operating such a portfolio of business activities poses important managerial challenges forcing corporations to continuously re-consider their vertical and horizontal scope and boundaries.

The course Corporate Strategy draws from a wide range of theories and methods to develop an understanding of the conceptual frameworks, debates, and developments concerning decisions associated with the management of multi-business corporations. We will cover the key questions driving a firm's corporate strategy, including:

- In what markets to compete with which businesses?
- Which activities should be performed by the firm and which should be outsourced (i.e. "make" or "buy" decisions)?
- What are the most appropriate approaches to growth and divestiture?
- How do institutional forces impact corporate strategy?

Specifically, we will examine how organizations manage their portfolio of business activities and markets to achieve competitive advantage through vertical integration, cooperative strategies such as strategic alliances and joint ventures, corporate diversification, mergers and acquisitions, divestitures, and globalization/international strategies, and strategic renewal.

Please register through myStudies to enroll for the course. Slots are assigned on a first-come first-serve basis (in the order of the registration date on myStudies). We will confirm your registration by e-mail. If you have any inquiries about the course, please contact the course assistant.

The course homepage can be found at: http://www.smi.ethz.ch/education/corporate-strategy.html

The three case studies presented in this course cover real managerial issues of the Swiss manufacturer Bühler AG (www.buhlergroup.com). A Bühler top executive will present the cases and discuss the students' presentations and solutions. As such, the course allows for in-depth discussions of the real-life case solution with the C-level manager and hereby enables students to transfer their learnings from theoretical considerations to the applied field. The course will be rounded off with a day visit to the Bühler facilities in Uzwil, Switzerland, where students will have the chance to further connect with management and discuss the acquired key concepts, tools, and case study insights on-site.

In addition to course enrolment, students have to apply for this course by sending a CV and a short motivation letter until 31.08.2023 to Dr. Theresa Schachner: t.schachner@ethz.ch.

The seminar "Cases in Technology Marketing" introduces students to key concepts and tools in technology marketing and familiarizes them with the challenges that (marketing) managers face in technology-intensive markets by using real-life cases. Students will have to work in groups and together solve past, current and future managerial problems in the form of cases. The team member composition will rotate for each case, enabling students to foster their teamwork abilities besides the application of theoretical concepts to the applied case questions. The students will have to present their case solutions to the lecturer and a top executive of a leading Swiss company (details see below). Also, they will be enabled to compare their solutions with what has actually been done or is yet to be done.

Students apply for this course via the official website no later than 18.08.2024 (https://www.mtec.ethz.ch/studies/special-programmes/els.html). Once your application is confirmed, registration in...
myStudies is possible.

Abstract
This seminar provides master and PhD students at MTEC with the challenging opportunity of a real case on strategy, innovation and leadership in close collaboration with the senior management of a leading company: UBS.

Objective
The general objective of the course is to enable MTEC students to develop leadership skills by dealing with real-world business problems, thinking critically about the concepts discussed in their study programs and learning how to apply these concepts to provide practical implications. It provides students with coaching and mentoring from senior leaders in the company and professors from D-MTEC to bridge the gap between theory and practice.

Content
This seminar provides ambitious ETH students and doctoral candidates with a rewarding learning opportunity: a real case study of strategy and innovation in close collaboration with the top management of an outstanding company: UBS.

What you can expect:
You will work in teams on specific high priority assignments that flow from the company. Delving into the assignments you will both contribute to solving strategic issues and have an impact on their implementation at the company.

To gain insight into the company and its culture you will receive briefings from senior management, conduct interviews with experts and run workshops with your case managers. In the final presentations you will pitch your findings to key stakeholders and top management representatives and receive valuable feedback.

Furthermore you will be coached and supported by MTEC professors on the topics of project scoping, problem definition and solving, process improvement, strategy and board presentation.

The course is directed and organized by PD. Dr. Zeynep Erden and Dr. Isabel Spicker as part of the MTEC Leadership Development Programme.

What we expect from you:
You are an ambitious ETH student or doctoral candidate who is looking for a rewarding learning opportunity and is eager to go the extra mile. You will work on a real case study of strategy, technology and innovation in close collaboration with the senior management of an outstanding company. The recommendations that you formulate in collaboration with members of your team as well as with internal and external experts will be discussed at the partner and director levels. This demands a deep understanding of the company’s leadership culture.

In this endeavour, you are coached and supported by
- Stefano Brusoni, Chair of Technology and Innovation Management
- Georg von Krogh, Chair of Strategic Management and Innovation
- Oliver von Dzengelevski, Chair of Production and Operations Management
- Zeynep Erden, Lecturer, D-MTEC
- Isabel Spicker, D-MTEC

Literature
Literature and readings will be announced in the coaching sessions.

Prerequisites / notice
Please apply for this course via the official website (https://mtec.ethz.ch/studies/programme-elements/special-programmes/els.html). Apply no later than August 18, 2024.

The number of participants is limited to 18.

ECTS: 4
Participants receive a certificate.

Competencies
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Industry and Competitive Analysis
Industry and Competitive Analysis (ICA) is an essential part of any strategic management process. It contains a very practical set of methods to quickly gain a good grasp of an industry. The purpose of ICA is to understand factors that influence the financial performance of an industry and firms within that industry, thereby enabling firms to develop effective competitive strategies.

Abstract
Industry and Competitive Analysis (ICA) is an essential part of any strategic management process. It contains a very practical set of methods to quickly gain a good grasp of an industry. The purpose of ICA is to understand factors that influence the financial performance of an industry and firms within that industry, thereby enabling firms to develop effective competitive strategies.

Objective
Goals of the course
- Students will develop an in-depth understanding of how the structure of an industry impacts both industry-level and firm-level performance.
- Students will develop practical skills in analyzing industries and firms within them.
- Students will gain a broad understanding of the impact of digitalization on various industries and develop an in-depth understanding of (at least) one chosen industry.
- Students will improve the analytical skills needed to successfully compete in the digital age.

363-0404-00L

Autumn Semester 2024
Industry and Competitive Analysis (ICA) is an essential part of any strategic management process in firms and other organizations. It contains a very practical set of methods to quickly gain a good grasp of an industry, be it pharmaceuticals, information and communication technology, professional services, or even the beer industry. The purpose of ICA is to understand factors that influence the performance of an industry and firms within that industry. Gaining such understanding supports firms in developing effective competitive strategies.

As the world witnesses tremendous development in digital technologies, many industries are in the midst of transitioning from analogue to digital business models. Digitalization is radically changing what firms produce and the way they organize their business activities. To adapt to these changes, practitioners and scholars alike need a more advanced set of analytical tools to understand the constantly-changing industries. That is why we have developed our course as ICA 2.0, which provides state-of-the-art tools to gain an updated picture of various industries before and after their digital transformation. In this course, we will study theoretical frameworks, examine evidence from empirical research, and benefit from expertise shared by our guest speakers.

The course is organized into thirteen sessions that comprise a combination of (guests) lectures, case studies, and (tutored) group work. The schedule is subject to change, depending on the availability of the guest lecturers.

This course requires preparation time and completion of assignments is required to receive the credit. Participation in both sessions and completion of all registrations will be handled on a case-by-case basis. Note that class participation is important. Students should make sure that they can attend each weekly lecture prior to registration.

Note that class participation is important. Students should make sure that they can attend each weekly lecture prior to registration. Experience in statistical analysis with tools such as SPSS or equivalents is an advantage.

### Literature

This course is built upon a management classic (Competitive Strategy: Techniques for Analyzing Industries and Competitors by Porter, 2004). We also draw from more recent research findings and practitioner-oriented strategy research. Students are expected to familiarize themselves with the assigned readings and develop a thorough understanding of the material before coming to class. For students wishing to explore the course content in greater depth, optional readings are proposed for each session. We will share the course literature and case material on the Moodle course page, which is accessible to students who have successfully enrolled to the course in myStudies.

### Prerequisites / notice

Experience in statistical analysis with tools such as SPSS or equivalents is an advantage.

### Competencies

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### 363-0887-00L Management Research

Participation in both sessions and completion of all assignments is required to receive the credit. This course requires preparation time and completion of an assignment before the first course day. Please check the Moodle course page for more information.
Abstract
You will learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop your own research projects.

Objective
- Think critically and make compelling arguments about the strengths and weaknesses of published management research
- Find and review appropriate literature and previous research for your thesis
- Develop and frame interesting and relevant research questions and problem statements
- Design your research and choose an appropriate methodology for analysis (specific research methods and techniques are not discussed in this course)
- Structure your manuscript
- Plan and manage your thesis project

Content
This course combines lectures, group discussions and individual assignments.

Day 1: Course introduction, group analysis exercises and discussions, lectures on main topics.
Day 2: Assignment review and discussion, lectures on main topics, conclusion session.

Target audience:
The course is designed with two groups of students in mind: first, students who write their master thesis at the SMI chair and second, students who write their master thesis in the field of management at other MTEC chairs.

For both groups, the focal topics of this course will arise frequently during the journey of writing their thesis, and the majority of topics are relevant for all students. However, we will provide some specific content (grading guidelines, thesis format) which might not be applicable for students tutored at other MTEC chairs.

Course topics:
1. Thesis topic and thesis proposal:
   - Choice of thesis topic, identification of research gap, formulation of research questions, writing of thesis proposal
2. Literature review:
   - Search and evaluation of academic literature, use of reference tools, writing of theoretical background chapter of thesis
3. Empirical research design:
   - Types of empirical research designs, choice of methodology, overview of data collection and analysis methods
4. Research output and report:
   - Writing of introduction, results and conclusion, thesis format and structure
5. Thesis assessment:
   - SMI grading criteria, MTEC guidelines

References:

Prerequisites / notice
This course is for all students who write their master thesis at the Department of Management, Technology, and Economics.

The course is required for all M.Sc. students and MAS students who write their master thesis at the Chair of Strategic Management and Innovation.

The course is graded based on the assignments, peer feedback, and participation in group discussions.

Enrolment only with simultaneous submission of a short letter of motivation (max. 1 A4 page) plus CV. Students have to apply for this course by sending a CV and a one-page motivation letter until 31.08.2024 to David Baschung (mailto:dbaschun@ethz.ch). Additionally, please enroll via myStudies. Places will be assigned on the basis of your motivation letter.

In this seminar you will learn how to quickly develop useful solutions in complex situations under time pressure and with incomplete information using a heuristic process as a person in charge (e.g. team leader).

After taking this course, students will be able to:
- develop useful solutions independently and in good time in situations with limited information and time constraints (personal competences, application);
- use heuristic procedures to reduce complex problems and make them solvable in an ad hoc context (methodological competences, application);
- develop and present concepts in groups and reflect on the interpersonal challenges in such contexts (social skills, application and understanding);
- bring in specialised knowledge from other courses in order to recognise the connections between business planning and scientific research (discursive skills, understanding);
- gain initial personal experience in the management and leadership of crises (experiential knowledge).
The aim of the seminar is to develop a real crisis case during a two-day block at a major international manufacturing company in the Lucerne area and to present the results to selected managers of the company. In the first part of the semester, you will learn the elements of a generic heuristic problem-solving procedure step by step in 4 double lessons. You will be taught the theoretical basis and then given a small business case, which you will solve in small groups using the newly learnt process steps until the following course. In the following week, you will reflect on the solutions together and receive feedback from the lecturer (without marks to encourage free learning). At the end of the preparation period, you will receive selected documents from a Swiss industrial company, which you will analyse to be ready for the visit to this company in the second part of the course.

In the second part, we visit an industrial company in Central Switzerland. Company representatives will present us with specific current challenges to which we will develop practical answers in small teams over the course of two days. This process is accompanied by team external coaches with relevant experience in leadership and management. Selected performances (oral and written) of these block days are graded, but the actual group work is ungraded to favour creative and innovative approaches. At the end of the two days, we present the proposed solutions to some of the company's executives. During the working days, you will also have time to get to know managers from the renowned family business in a relaxed atmosphere and expand your network accordingly (lunch, drinks reception, Q&A sessions).

To ensure learning success, the project outlined in the teamwork is further developed in writing in the remaining part of the semester and submitted as a term paper. This work is assessed and accounts for a total of 50% of the grade. At the end of the semester, achievements are recognised, and feedback is exchanged between lecturers and students.

Lecture notes
Will be made available from week to week via Moodle.

Literature

Prerequisites / notice
A maximum of 20 students to enable intensive support from the coaches and to ensure an immersive experience with the industry partner.

In addition to course enrolment, students have to apply for this course by sending a by sending a CV and a one-page motivation letter until 31.08.2024 to David Baschung Link (mailto:dbaschung@ethz.ch).

Competencies
Subject-specific Competencies
- Concepts and Theories fostered
  - Techniques and Technologies fostered
- Analytical Competencies assessed
  - Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Method-specific Competencies
- Communication assessed
  - Cooperation and Teamwork fostered
  - Customer Orientation fostered
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity fostered
- Negotiation fostered

Social Competencies
- Adaptability and Flexibility fostered
  - Creative Thinking assessed
  - Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management assessed

Personal Competencies
- Self-awareness and Self-reflection fostered
- Leadership and Responsibility
- Customer Orientation assessed
- Media and Digital Technologies assessed
- Decision-making assessed
- Personal Competencies assessed
- Social Competencies assessed

363-1193-00L Strategic Foresight for Sustainable Futures W 3 credits 2V J. Heck, C. Luebkeman

Abstract
Students will learn about strategic foresight in the context of sustainable futures that incorporate principles of regeneration, resilience, and circularity. Foresight is an approach that scientists, government officials, and business executives use to explore and reflect on potential future challenges. The course will explore tools and techniques to advance our understanding of possible futures.

Objective
After completing the course, students will be able to:
- Discuss the value of foresight and how to use it.
- Execute activities to gather intelligence about future contexts.
- Organise and analyse drivers to explore the dynamics of change.
- Independently develop scenarios based on current best practices.
- Systematically analyse scenario implications and evaluate their relative value.

Content
The course is for Master (and PhD) students who want to develop their long-term thinking and leadership skills and are curious about sustainability and regeneration. Students will benefit from their own practice-oriented learning experience covering the foresight process and a deep dive into scenario-building methods and their concrete applications. The student number is limited; we select from a diverse group with interdisciplinary backgrounds.

This course is project-based and guided by the question: “Given that Switzerland will continue to experience significant climate change, what will sustainable energy/mobility/food production etc. scenarios for Switzerland look like, and how will we get there?” Students will work in groups to explore the different methods, building up a coherent understanding of Strategic Foresight applied to real-world contexts. The methods are analytical and creative, training students in openness and curiosity. The class requires hands-on engagement with the learning process. The lecturers will provide inputs and access to experts, and students will actively use the methods presented to develop realistic, valuable scenarios.

The case context will be sustainability linked to Swiss energy/mobility/food etc... Students will independently explore different aspects of this case and, in doing so, will meaningfully contribute to their learning and the ongoing work within ETH and the higher education sector about how universities may contribute to positive change in society. Students will develop their own scenarios in groups and present them at the end of the course. The course covers four phases of Strategic Foresight: (1) gathering intelligence about the future, (2) exploring dynamics of change, (3) describing what the future might be like, and (4) developing and testing strategies.
Competencies

Subject-specific Competencies

Concepts and Theories fostered
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Method-specific Competencies

Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies

Communication fostered
Cooperation and Teamwork fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity assessed
Negotiation fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Additional Courses

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<tr>
<td>Abstract</td>
<td>The semester project (90 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>363-0883-00L</td>
<td>Semester Project Large</td>
<td>W</td>
<td>6 credits</td>
<td>13A</td>
<td>Professors</td>
</tr>
<tr>
<td>Abstract</td>
<td>The semester project (180 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.</td>
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</tr>
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<td></td>
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</tr>
</tbody>
</table>

Supplementary Courses

The students have to deepen their knowledge in the area(s) of engineering/natural sciences in consultation with the responsible professor (tutor). Core courses and electives of D-MTEC can not be used as supplementary courses.

Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0879-00L</td>
<td>Practical Training</td>
<td>O</td>
<td>6 credits</td>
<td>external organisers</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The practical experience gained by the student complets the studies at the Swiss Federal Institute of Technology and prepares her/him for future activities in industry.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</tr>
</tbody>
</table>

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0600-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>57D</td>
<td>Professors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Only students who fulfill the following criteria are allowed to begin with their master thesis: a. successful completion of the bachelor programme; b. fulfilling of any additional requirements necessary to gain admission to the master programme; c. internship fulfilled; d. academic writing course has been completed.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Objective</td>
<td>In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is supervised by the tutor and normally deals with a subject contained in the major fields. The research will be performed normally within a private company or at the ETH Zurich.</td>
<td></td>
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</tr>
<tr>
<td>363-1063-00L</td>
<td>Academic Writing Course</td>
<td>O</td>
<td>0 credits</td>
<td>3G</td>
<td>R. Mihalka</td>
</tr>
<tr>
<td>Abstract</td>
<td>Compulsory for all MTEC MSc students. Attendance of the initial lecture is compulsory. Students who are unavailable at the time of the initial lecture need to take the course in another semester.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>This course for MTEC MSc students focuses on developing students' English writing skills and their understanding of the disciplinary expectations for academic texts. The course is particularly designed to support students in writing their theses.</td>
<td></td>
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</tr>
</tbody>
</table>
Objective
After the completion of the course, students are able to:
- understand the concept of plagiarism and cite their sources accurately and appropriately,
- plan the writing process efficiently,
- analyse model texts from the perspective of language use,
- plan, draft, and revise academic texts,
- provide peer review on others’ writing,
- write in a clear, precise, concise, and generally reader-friendly manner,
- use generative AI tools for writing without compromising their scientific integrity.

Content
Initial lecture: Writing at MSc level in D-MTEC, avoiding plagiarism, course overview
Workshop 1: The writing process
Workshop 2: Paragraph structure
Workshop 3: Methods
Workshop 4: Figures and tables
Workshop 5: Literature review
Workshop 6: Introduction
Workshop 7: Results, Discussion, Conclusion
Workshop 8: Abstract and Title

Lecture notes
Handouts and self-study materials are available on Moodle.

Prerequisites / notice
First-year students who participated in the lecture on plagiarism on the first day of studies will have a different schedule from other students. Please refer to the lecturer’s message for details, which will be sent out a week before the initial lecture.

Competencies
Method-specific Competencies
Analytical Competencies
Media and Digital Technologies
fostered
Social Competencies
Communication
assessed
Cooperation and Teamwork
fostered
Personal Competencies
Critical Thinking
fostered
Integrity and Work Ethics
fostered
Self-awareness and Self-reflection
fostered
Self-direction and Self-management
assessed

Management, Technology and Economics Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Advanced Fundamentals of Mechatronics Engineering

Advanced Fundamentals

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>173-0005-00L</td>
<td>Materials for Engineers</td>
<td>O</td>
<td>6</td>
<td>13G</td>
<td>R. Spolenak</td>
</tr>
<tr>
<td>Abstract</td>
<td>The appropriate processing-microstructure-property relationship will lead to the fundamental understanding of concepts that determine the mechanical and functional properties of materials. Materials and process selection will be core to this course. The lab sections and group projects will provide students with valuable hands-on experience.</td>
<td></td>
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</tr>
</tbody>
</table>
| Objective | At the end of the course, the student will be able to:  
  • choose the appropriate material for mechanical engineering applications  
  • improve on critical thinking and quantitative reasoning in order to learn and apply the theoretical foundation of the course to critical real-life problems.  
  • develop the technological competence to combine theory as well as analytical and computational simulation approaches to address structural problems.  
  • use materials selection software, 3D modelling, manufacturing or workshop tools, and materials testing equipment.  
  • apply manufacturing processes to a designed product.  
  • produce coherent and scientifically sound laboratory reports.  
  • provide leadership and teamwork spirit. |
| Literature | The material will be organized in lecture slides. |
| 173-0007-00L | Dynamics                     | O    | 6    | 13G   | E. Chatzi, V. Ntertimanis, P. Tiso |
| Abstract | The course offers an introduction to dynamics of engineering systems. The first part focuses on Newtonian dynamics and energy principle to systems of particles and rigid bodies. The second part focuses on the free and forced response of single- and multi-degrees-of-freedom linear systems. Hands-on exercises, computer-based labs and experimental demos will support the theoretical lectures. |
| Objective | After successful completion of this course the students will be able to:  
  1. Set up the kinematic description of a system of particles and rigid bodies subject to constraints.  
  2. Formulate the governing equations of motion of a system particles or of rigid bodies using balance law.  
  3. Alternative from the above, the student will be able to derive the equations of motion using Lagrange's equations, d'Almbert's principle, and Hamilton's principle.  
  4. Find the equilibrium configurations of a given system, and perform linearization.  
  5. Compute the dynamic response of discrete systems to harmonic, periodic, pulse, and impulse excitation using time-history and response-spectrum methods. |
| Content | Day-by-day course content:  
  Week 1  
  Day 1 – Recap on Newtonian Dynamics for single particle  
  Day 2 – Kinetics of systems of particles  
  Day 3 – Kinetics of Rigid bodies  
  Day 4 – Analytical mechanics  
  Week 2  
  Day 6 – Mechanical Vibrations  
  Day 7 – Elements of Structural Vibration - SDOF  
  Day 8 – Elements of Vibration Theory - MDOF  
  Day 9 – State Space Representations  
  Day 10 – Transformations |
| Lecture notes | The material will be organized in lecture slides. |
| Literature | A specific list of books will be offered as useful/supplemental reading. |
| 173-0009-00L | Statics and Solid Mechanics   | O    | 6    | 13G   | E. Mazza, R. Hopf       |
| Abstract | The course introduces general methods for the analysis of stress and deformation states in mechanical parts, as needed to optimize their design and to ensure their mechanical integrity. Starting from the derivation of the basic principles, the concepts are extended to consider anisotropic materials, plasticity, viscoelasticity and viscoplasticity. Examples of engineering applications are discussed. |
| Objective | The students will be able to analyse mechanical problems, to formulate and apply design criteria involving strength, local plastification, structural mechanics, particularly including the finite element (FE) method for static and dynamic problems. To understand the structure of FE codes and the right use of FE technology. |
| Competencies | Subject-specific Competencies  
  Concepts and Theories  
  Techniques and Technologies  
  Method-specific Competencies  
  Analytical Competencies  
  Decision-making  
  Problem-solving  
  Social Competencies  
  Communication  
  Personal Competencies  
  Creative Thinking  
  Critical Thinking |
| Literature | The material will be organized in lecture slides. |
| 173-0100-00L | Computational Methods        | O    | 6    | 13G   | D. Kochmann, L. De Lorenzis |
| Abstract | This course introduces students to numerical methods commonly used in engineering with a focus on finite element (FE) analysis. Starting with finite differences and ending with static and dynamic FE problems, students will learn the fundamental concepts of finite elements as well as their implementation and application. |
| Objective | To understand the concepts and application of numerical techniques for the solution of initial boundary value problems in solid and structural mechanics, particularly including the finite element (FE) method for static and dynamic problems. To understand the structure of FE codes and the right use of FE technology. |
| Content | Numerical methods and techniques for solving initial boundary value problems in engineering solid mechanics (heat conduction, static and dynamic mechanics problems of solids and structures). Finite difference methods, indirect and direct techniques, variational methods, main focus on the finite element (FE) method, FE analysis in small strains for applications in structural mechanics and solid mechanics. |
| Lecture notes | Typed lecture notes will be made available online. |

Industry Internship
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>173-0011-00L</td>
<td>Internship</td>
<td>O</td>
<td>5 credits</td>
<td>11P</td>
<td>M. Zeilinger</td>
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</table>

**Master’s Thesis**

Offered in the Autumn Semester. Offered for the first time in HS 2024.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>173-0012-00L</td>
<td>MAS-Thesis</td>
<td>O</td>
<td>5 credits</td>
<td>11D</td>
<td>Professors</td>
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**MAS in Advanced Fundamentals of Mechatronics Engineering - Key for Type**

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<thead>
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<th>Compulsory</th>
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</tr>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
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<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
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<td>A</td>
<td>independent project</td>
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<tr>
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<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

**ECTS** European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in AI and Digital Technology

- Compulsory Modules
- Integration Modules and AI Project
- Master's Thesis

Key for Hours

<table>
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ECTS European Credit Transfer and Accumulation System

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MAS in Applied Technology

Major in Applied Information Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>265-0100-00L</td>
<td>Foundations of Programming</td>
<td>O</td>
<td>2</td>
<td>2A</td>
<td>L. E. Fässler</td>
</tr>
</tbody>
</table>

Abstract
The initial module offers a practical introduction to some basic concepts and techniques for information processing as well as practical applications of them. The programming language are Python and SQL.

Objective
Participants learn...
- how to encode a problem into a program, test the program, and correct errors.
- to understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- query databases and understand and evaluate the corresponding database model.
- to implement mathematical models as a simulation.

Content
The following programming concepts are introduced during this module:

1. Variables, data types
2. Condition check, loops, logics
3. Sequential data types
4. Functions and Modules

In the practical part of the course, students work on small programming projects with a context from natural sciences. Electronic tutorials are available as preparation.

Prerequisites / notice
No prior knowledge is required for this course. It is based on application-oriented learning. The students spend most of their time working through programming projects and discussing their results with teaching assistants. To learn the programming basics there are electronic tutorials available.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>fostered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>fostered</td>
</tr>
</tbody>
</table>

Social Competencies

- Communication
  - fostered

Personal Competencies

- Adaptability and Flexibility
  - fostered
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Self-awareness and Self-reflection
  - fostered
- Self-direction and Self-management
  - fostered

265-0101-00L Data Science: From Analytics to Learning  O  4 credits  3V  O. Akkus Ispir, E. Konukoglu

Abstract
In this module, basic paradigms and techniques in working with data will be discussed, especially towards data security, managing data decentrally, and learning from data.

Objective
Participants will understand some of the concepts in detail and see the mathematics behind them.

Content
The module in particular covers cryptography and digital signatures, networking and distributed algorithms, distributed ledger technology, as well as machine learning (supervised and unsupervised learning). For each topic, there will be a hands-on and in-depth introduction that allows participants to gain a technical understanding of key ideas. This is supported by simple and concrete examples as well as programming assignments.

265-0102-00L Computer Vision Basics  O  2 credits  2V  E. Konukoglu

Abstract
This module will cover basic theoretical knowledge on visual recognition systems of the last two decades, mostly focusing on the most recent advancements in deep learning and convolutional neural networks.

Objective
Participants understand basic concepts of visual recognition and human-computer interaction systems.

Content
The content starts with an introduction to neural networks and then focuses on how they are used for computer vision tasks. The theoretical knowledge will be supported with a practical session that will allow participants to gain hands-on experience with most commonly used tools and deepen their understanding of the key concepts with examples.

265-0104-00L Reinforcement Learning Basics  W  2 credits  2V  B. Grewe

265-0105-00L Ethics, Leadership & Communication in Data-Science  W  2 credits  2V  O. Akkus Ispir

Major in Applied Manufacturing Technology

Offered only in the Spring Semester.

Focus Courses Energy or Electronics and Digitization

Offered only in the Spring Semester.

Major in CAS in Applied Technology: R&D and Innovation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>247-0200-00L</td>
<td>Fundamentals of R&amp;D and Innovation</td>
<td>O</td>
<td>4</td>
<td>2G</td>
<td>U. Grossner, C. Ganz</td>
</tr>
</tbody>
</table>
The goal of this module is to complete the R&D and innovation framework and make the key points available in the context of the organization's environment. Participants will learn how to organize, conduct and manage individual R&D projects as well as groups of projects. Special emphasis will be given to scientific and technical reporting.

Lecture notes
The module will be based on a self-study Polybook.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>fostered</td>
<td>fostered</td>
<td>fostered</td>
<td>fostered</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Communication</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>fostered</td>
<td>fostered</td>
<td>fostered</td>
<td>fostered</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>fostered</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
</tr>
<tr>
<td>assessed</td>
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<td>Customer Orientation</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fostered</td>
<td></td>
</tr>
<tr>
<td>Fostered Social Competencies</td>
<td>Fostered Method-specific Competencies</td>
<td>Fostered Social Competencies</td>
<td>Fostered Personal Competencies</td>
</tr>
</tbody>
</table>

247-0201-00L Innovation – What Is and to What Purpose Do We Need It?  
Objective: In this module, participants will understand the diverse aspects of these phases and the impact on the organization and governance.

Content
In this module, we will look at these various aspects of innovation beyond the own organization. This module will wrap up the CAS and put the material in context of the organization's environment.

247-0202-00L R&D: The Engine of Innovation
Objective: The aim of this course is to develop the participants' ability to articulate a coherent plan for R&D activities linked to the business needs of a corporation, and to set the environment to enable an efficient R&D organization.

Content
In most organizations, the R&D organization is the one that delivers the innovation to be brought to the market. In this module, we investigate the inner working of the R&D organization by exploring roles and processes. Since R&D almost always starts with significant uncertainties and unsolved technical problems, governing R&D has to account for these unknowns. As R&D processes take time in which the market environment may change in ways other than predicted at the beginning of a project, external influences have to be continuously monitored as well to enable market success.

247-0203-00L The Innovation Ecosystem
Objective: This module wraps up the various aspects of innovation beyond the own organization.

Content
Successful innovation builds on a whole ecosystem of contributors: customer co-creation, university collaboration, strategic partnerships, or start-up investments are just a few examples of activities where other players may expedite the innovation process. Other aspects of the environment of innovation covers intellectual property strategy, or standardization and certification. In addition to successfully operating in the existing business ecosystem, innovation may transform it, or even create new ecosystems, with innovative business models.

In this module we will look at these various aspects of innovation beyond the own organization. This module will wrap up the CAS and put the material in context of the organization's environment.

Experimental Project
Offered only in the Spring Semester.

Master's Thesis
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
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<td>Master's Thesis</td>
<td>O</td>
<td>10</td>
<td>21D</td>
<td>Professors</td>
</tr>
</tbody>
</table>
Abstract
The topic of the independent Master’s thesis should focus on a technical problem and can be related to a specific business case. The problem and technology evaluated are freely selectable, but must be approved in advance by the thesis supervisor.

Objective
The thesis should be integrative of the science and technology material and skills learned during the programme, particularly:

- Understand and apply the foundations of the area of science and technology relevant to the topic,
- Understand and describe the technical barriers to applying a technology successfully, and
- Respective documentation using precise and targeted technical language.

MAS in Applied Technology - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E+</td>
<td>Recommended, not eligible for credits</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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Key for Hours

<table>
<thead>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
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</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Architecture and Digital Fabrication

The MAS Digital Fabrication is a 1 year full-time programme and is structured as a series of teaching modules with an independent master thesis. Lessons within the modules are given in the form of lectures, practical workshops, and projects as the main modus for developing skills. Learning will be supported through one on one mentoring in studio, group critiques, symposia, and excursions.

Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>069-0001-00L</td>
<td>Digital Foundations</td>
<td>O</td>
<td>20</td>
<td>2G</td>
<td>B. Dillenburger, F. Gramazio, M. Kohler</td>
</tr>
</tbody>
</table>

Abstract
Digital Foundations introduces students to information technology in architecture, to computational design and how robotic fabrication processes as well as 3D printing technologies are used to translate computational design models into physical objects and building components.

Objective
Students learn basic programming paradigms such as control structures and object oriented programming, the foundations of computational geometry and explore generative form-finding. Using Python as a main programming language within the frameworks of Processing, Rhino and Grasshopper, students learn to translate design thinking into computational algorithms. Furthermore, students learn about data preparation and toolpath creation for 3D printing (predominantly binder jet-printing and fused-deposition-modelling), and familiarise themselves with various mechatronic setups, materials and control-strategies of additive manufacturing.

Students are taught the basic principles of working with industrial robotic arms in the field of architecture. Students practice different concepts of robotic control, which enables them to execute basic routines. They are able to write their own programmes and directly control the robotic set-up using UR-Script and custom Python modules. Through multiple exercises, students learn how to design and robotically build small-scale spatial structures exhibiting the potential of robotic fabrication processes. Additionally, they employ simple feedback loops for improving the accuracy of the fabrication process and as design-drivers.

MAS in Architecture and Digital Fabrication - Key for Type

<table>
<thead>
<tr>
<th>O</th>
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Key for Hours

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ECTS
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### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>072-0001-00L</td>
<td>Construction Industry and Real Estate Market</td>
<td>O</td>
<td>3 credits</td>
<td>7G</td>
<td>S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

In the first term of MAS ETH ARC, the students knowledge of the construction sector and the real estate market will be reinforced and deepened, along for an informed interpretation of the stakeholders' decision making processes. It explores the topics of involved parties and perception of demand. Additionally, it will guide students in developing their research proposals and research questions.

**Objective**

The first term of MAS ETH ARC supports the students' expertise and personal skills and develops their reasoning and creative thinking skills. It compels the students to understand both ambitious projects and complex properties, to pursue long-term intentions, to carry out specific tasks, and to become aware of the consequences of their decisions. Over the course unit, students review and closely examine the expertise which they have gained so far. The course directs students to draw independent conclusions and to set forecasts as professionals. Ultimately, the knowledge and expertise which is gained throughout the unit will allow the students to fully realise their role as a professional in their field.

**Content**

In the first term of MAS ETH ARC, the students knowledge of the construction sector and the real estate market will be reinforced and deepened, along for an informed interpretation of the stakeholders’ decision making processes and interests. It also explores the topics of involved parties and perception of demand. Additionally, it will guide students in developing their research proposals and research questions.

Key words of the course unit

Project and property, design and building process, involved parties and services, interests, basic knowledge and terms, perception and dissociation, sustainable decisions, and life cycle

MAS thesis

Aiding students on potential research, in light of students' interests, work and academic experience, and their professional aims.

Assisting students with determining the relevance of the study area. Discourse, developing the research objectives and devising the research questions. Public presentation of the final objectives.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>072-0003-00L</td>
<td>Methodology</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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</table>

**Abstract**

In the fourth term of MAS ETH ARC, the students will guide through the process of methodology which is the ability to put their attitude into practice. Additionally, the course unit puts emphasis on the research findings and finalisation of the written work.

**Objective**

The fourth term of MAS ETH ARC supports the students' attitude and practice and methodology. It compels the students to analyse issues and carry out solutions. Ultimately, the knowledge and expertise which is gained throughout the unit will allow the students to fully realise their role as a professional in their field.

**Content**

In the fourth term of MAS ETH ARC, the students will guide through the process of methodology which is the ability to put their attitude into practice. Additionally, the course unit puts emphasis on the research findings and finalisation of the written work.

Key words of the course unit

Objectives, methodology, research, analysis and interpretation, academic writing, text understanding, publishing

MAS thesis

Aiding students on potential research, in light of students' interests, work and academic experience, and their professional aims.

Assisting students with developing the research objectives and devising the research questions, illustrating the methodology, defining the contents, publicising their thesis. Public presentation of the objectives.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

### Core Courses

#### Module 1: Foundations of Digitalisation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>072-0101-00L</td>
<td>Module 1: Foundations of Digitalisation</td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Key terms: Digital transformation is more than digitisation of existing processes and information. Independently of the building industry, Module 1 initially provides information about the characteristics of digitalisation through its principles and rules, enabling the participants to independently recognise the short-term and long-term changes that are resulting from it.

**Objective**

The first module addresses the topic of digitalisation and digital transformation in a holistic sense. It is much more than converting documents into PDFs or using software. It is about transforming processes, resources and information into a consistent and efficient digital system to make life easier for employees and customers. This journey always involves change. From the perspective of other industries, we first build up a basic understanding and discuss the opportunities and risks.

**Content**

How do the experiences of other industries help us? What can be derived from them? Why is BIM only a small part and why is the future of BIM not BIM?

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>072-0102-00L</td>
<td>Module 2: Collaboration</td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Key terms: “Behaviour for Collaboration” - Structural questions on collaboration and the patterns of behaviour. In Module 2, we break from the theoretical idea of a purely technology-based, better collaboration and look at the situation realistically in order to be able to understand and develop new solutions and requirements.

**Objective**

The usual approach towards digital transformation is to train people to use new technologies. In contrary, we ask for the specific challenges and problems people have with change. We learn to understand viewpoints of different partners within building projects and new solutions to specific problems.

**Content**

Assisting students with determining the relevance of the study area. Discourse, developing the research objectives and devising the research questions. Public presentation of the initial objectives.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

<table>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>072-0103-00L</td>
<td>Module 3: Foundation of Automation</td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Key terms: Managed data, semantics and file formats. Module 3 we leave behind the negative images from the early days of automation. A gloomy and misanthropic image of automation - both a bliss and a curse. We get to know the positive sides and learn to apply them. How do we become a sustainable "Formula 1"?
What does it take to be able to work together in a digitally networked environment? How many "techie genes" are needed to work efficiently and effectively with structured data? The third module gives an insight into the principles of data architectures, data formats, attributes and platform technology. Machine readability as an important requirement but also as a clear challenge e.g. to security requirements.

The module offers the opportunity to prepare for the voluntary buildingSMART Professional Certification.

The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.

### Literature

- Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

#### Module 4: Foundation of Value Creation

**Number:** 072-0104-00L  
**Title:** Module 4: Foundation of Value Creation  
**Type:** W  
**ECTS:** 1  
**Hours:** 2G  
**Lecturers:** A. Paulus, S. Menz

**Abstract:** Key terms: Added value of digital transformation, distributed data management, digital twin, logistics and robotics.

**Objective:** Using specific examples, Module 4 illustrates the foundations and versatility of building information modeling (BIM), enabling participants to deal with the concepts, applications and mechanisms involved.

**Content:** "Highway to hell or highway to haven" - the question of a clear and simple roadmap is always at the heart of a digital transformation. "Value creation" is a central goal. Digitalisation is often seen as a strategy from the productivity gap. The fourth module shows how strategic goals can be developed in a roadmap and implemented in practice and how the individual shareholders and stakeholders participate.

We learn to consciously look at the topic of added value and digital transformation from different perspectives. Collision checking and quantity take-offs (QTO) are very useful. But they are only basics when it comes to real value creation.

**Lecture notes**  
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

**Literature**  
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

#### Module 5: New Business Models

**Number:** 072-0105-00L  
**Title:** Module 5: New Business Models  
**Type:** W  
**ECTS:** 1  
**Hours:** 2G  
**Lecturers:** A. Paulus, S. Menz

**Abstract:** Key terms: Business models, cultural change, disruption, evolution, lean methods

**Objective:** Module 5 focuses on cultural change, innovation, disruption or evolution? In this last module, we learn to question and discover what the 17 Sustainable Goals mean for our industry.

**Content:** As a final module, new business models are discussed and explored. Examples will be used to explore patterns and interfaces and to analyse what is needed today and in the future for a successful and sustainable development of the sector. How can innovative ideas move us forward? What can we learn from design thinking? Why is it important for people to have useful and understandable measurable values? How do the 17 Sustainable Goals influence our industry?

We will analyse the topic on the basis of two concrete examples, familiarise ourselves with them and observe their further development as a result.

**Lecture notes**  
Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**  
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

<table>
<thead>
<tr>
<th>Term Paper</th>
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</table>

_The Term Paper is offered in spring semesters only._

### Major in Project Leadership

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Module 1: Understanding of Roles</th>
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</thead>
<tbody>
<tr>
<td>072-0201-00L</td>
<td>W 1 credit 2G A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**  
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

**Objective**  
The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.

- Profession
- Ethos and ethic
- Organisational forms
- Role and tasks
- Attitude and practice

**Content**  
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

**Lecture notes**  
Please find the teaching material, the further readings and Information on our server.

**Literature**  
www.map.arch.ethz.ch/en

<table>
<thead>
<tr>
<th>Number</th>
<th>Module 2: Collaboration</th>
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<tbody>
<tr>
<td>072-0202-00L</td>
<td>W 1 credit 2G A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**  
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

**Objective**  
The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.

- Organisation charts
- Project knowledge and process understanding
- Structure of the project
- Agile project management
- Socio-economic viewpoint
- Perception of demand

**Content**  
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

**Lecture notes**  
Please find the teaching material, the further readings and Information on our server.

**Literature**  
www.map.arch.ethz.ch/en

<table>
<thead>
<tr>
<th>Number</th>
<th>Module 3: Services</th>
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<tbody>
<tr>
<td>072-0203-00L</td>
<td>W 1 credit 2G A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**  
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

**Objective**  
The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.

- Phases and services
- Due diligence and duty of loyalty
- Duties and tasks, liability
- Working packages
- Management and coordination

**Content**  
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

**Lecture notes**  
Please find the teaching material, the further readings and Information on our server.

**Literature**  
www.map.arch.ethz.ch/en

<table>
<thead>
<tr>
<th>Number</th>
<th>Module 4: Guiding/Steering/Leading</th>
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<tbody>
<tr>
<td>072-0204-00L</td>
<td>W 1 credit 2G A. Paulus, S. Menz</td>
</tr>
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</table>

**Abstract**  
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.
The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.
- Management and administration
- Leadership
- Team performance
- Motivation and conflict resolution

Content
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Lecture notes
Please find the teaching material, the further readings and Information on our server.

Literature
www.map.arch.ethz.ch/en

<table>
<thead>
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<th>Objective</th>
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<th>Type</th>
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<tr>
<td></td>
<td>W 1 credit 2G</td>
<td></td>
<td></td>
<td></td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

Abstract
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Objective
The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.
- Management of unknowns
- Decision making
- Future perspectives
- Micro and macro environment
- Strength and flexibility

Content
Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Lecture notes
Please find the teaching material, the further readings and Information on our server.

Literature
www.map.arch.ethz.ch/en

### Term Paper

*The Term Paper is offered in spring semesters only.*

#### Major in Real Estate Strategies urban-peri-urban

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>072-0301-00L</td>
<td>Module 1: Perception of Demand</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Key words: construction and real estate market, micro and macro environment

**Objective**

In Module 1, by interpreting the snapshot of one's own enterprise and opportunities and dangers to appreciate.

**Content**

Introductory module «Enterprise» considers the roles of organizations in the economic network of markets and their identity. It presents the peculiarities of planning offices as a service provider, shows different types of companies and discusses the business cycle from founding to succession planning. In addition, the branch-specific development of leadership and organizational models as well as the problem of access to international markets are examined. Accompanying the basics of a general business model for service companies are taught and key criteria defined.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>072-0302-00L</td>
<td>Module 2: State of the Art</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Key words: Bauwerk Schweiz, new construction and renovation, economy

**Objective**

Change in value, demolition / replacement, potential for compression

**Content**

With more than CHF 3.585 billion (excluding land), Switzerland is the largest national capital. It grows by around 4.7% per cent each year, but its value is under-invested. Is there a risk of slippage? Should more be invested in maintenance / repair or more canceled and replaced? How big is the compaction potential in the stock? Excursus on civil engineering and infrastructure construction

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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</thead>
<tbody>
<tr>
<td>072-0303-00L</td>
<td>Module 3: Economic Interest</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Key words: intention development, realization operation

**Objective**

The participants understand a property in the context of a life cycle

**Content**

The importance of a life-cycle-oriented approach has arrived in the Swiss construction and real estate sector. Cumulative management costs can exceed the cost of construction after just a few years. In this module, a systematic consideration of the phases and processes in the life cycle of a property takes place. Study I explores various aspects of life-cycle planning and construction.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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</tr>
</thead>
<tbody>
<tr>
<td>072-0304-00L</td>
<td>Module 4: Course of Action</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Key words: maintenance, change, replacement

**Objective**

Preservation of value, increase in value, destruction of value and replacement construction

**Content**

The various depths of intervention in dealing with a existing property and their effects are known.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>072-0305-00L</td>
<td>Module 5: Life Cycle and Resources</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Key words: building fabric, material cycle

**Objective**

Production and disposal / reusability of building fabric, energy flows, pollutants

**Content**

Building and breaking off is understood as an energy and material flow.

**Lecture notes**

Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Literature**

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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The Term Paper is offered in spring semesters only.

**Core Courses**

**Module 1: Market**
- **Objective**: The aim is to become familiar with the tools used in marketing and able to use them in specific situations.
- **Content**: Marketing means orienting company activities towards market demands. Communication between suppliers, clients and the competition plays the decisive role here. The “marketing” module illustrates the foundations of marketing planning for architects and engineers. The essential definitions are provided and the core tasks involved in marketing are described. On this basis, the way in which a marketing plan is developed is explained and strategic and operational marketing planning is described in detail. The topics of branding and the opportunities represented by press and public relations work for architects and planners round out the “marketing” module.
- **Literature**: Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

**Module 2: Acquisition**
- **Objective**: The aim is to become able to analyse and implement the processes and instruments used for acquisition in one’s own company.
- **Content**: Acquisition represents a separate project in entrepreneurial activity, since all the activities involved in obtaining a commission fall under this term. The “acquisition” module focuses on imparting basic knowledge of networking and professional dialogue. Both of these tools require an assessment of one’s own situation with regard to competence, resources and customer relations. The conversation is a direct interaction; everyone involved is both an addressee and also basically an equal interlocutor. Networking can be learned: situational “small talk,” social competence and a healthy ability to communicate can be learned.
- **Literature**: Scripts, documents, studies, dates and addresses are stored on the server of the program.

**Module 3: Marketing**
- **Objective**: The aim is to become familiar with the tools used in marketing and able to use them in specific situations.
- **Content**: Marketing means orienting company activities towards market demands. Communication between suppliers, clients and the competition plays the decisive role here. The “marketing” module illustrates the foundations of marketing planning for architects and engineers. The essential definitions are provided and the core tasks involved in marketing are described. On this basis, the way in which a marketing plan is developed is explained and strategic and operational marketing planning is described in detail. The topics of branding and the opportunities represented by press and public relations work for architects and planners round out the “marketing” module.
- **Literature**: Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

**Module 4: Financial Management**
- **Objective**: The aim is to become familiar with the tools used in marketing and able to use them in specific situations.
- **Content**: Financial management means achieving the target company output with costs that are as low as possible, and in the longer term to create secure asset and capital structures. The tasks involved in financial management in a planning office include establishing a well-structured accounting department, careful cost accounting, sound budgeting and an effective controlling system. On the basis of a practical financial structure for architects and engineering offices, the “financial management” module presents the information needed to carry these tasks out in a professional and responsible way.
- **Literature**: Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

**Module 5: Digitalisation**
- **Objective**: The aim is to become familiar with the current practical work involved in IT in planning companies and be able both to analyze the specific challenges it implies and also to infer one’s own prospects for development in this context. In addition, thought needs to be given to the way in which the value creation provided by digitalisation influences one’s own company.
- **Content**: IT refers on the one hand to information and data processing in a company, and on the other to the hardware and software components needed for the purpose. This “information technology” module focuses on potential strategies for company management in the IT field. The focus is not on the use of any individual programme, but on taking conscious decisions for or against IT components in one’s own company in order to obtain helpful support in one’s everyday work. The strengths, weaknesses, opportunities and risk of this strategy suggest possible potentials.
- **Literature**: Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

**Term Paper**

The Term Paper is offered in spring semesters only.

**MAS in Architecture, Real Estate, Construction - Key for Type**

<table>
<thead>
<tr>
<th>Type</th>
<th>W+</th>
<th>W</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
</tr>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1622 of 2667
<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course/ private study</td>
</tr>
</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Field of Preservation

Core Courses and Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>079-0100-00L</td>
<td>Scientific questions of monument conservation practice</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>S. M. Schlachetzki, S. Langenberg</td>
</tr>
<tr>
<td>079-0101-00L</td>
<td>Seminar Texts on Preservation</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>R. Rehm</td>
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<tr>
<td>063-0911-24L</td>
<td>Future Monuments</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>S. Langenberg</td>
</tr>
</tbody>
</table>

Abstract

The seminar provides an introduction to the basics of working with heritage theory on a scientific basis. It imparts methodological knowledge, introduces participants to archive-based research, and enables them to critically evaluate the sources consulted. The subsequent communication of the results in the form of an expert's report is also part of the course.

Objective

The aim of the seminar is to qualify participants to apply methods of architectural and cultural studies in the evaluation of objects of the built environment. Participants are enabled to assess a selected building in the form of a heritage conservation expert's report.

Content

An essential basis for the responsible handling of the built heritage is the ability to recognize its characteristics and special features from an architectural-historical perspective and to objectively work out its historical testimonial value. This requires knowledge of scientific methods as well as the ability to undertake targeted research and critically evaluate source material in order to productively incorporate it into the analysis. The first part of the seminar is devoted to an introduction to academic work in the field of architecture and cultural studies. This lays the foundation for the second part which deals with the independent academic appraisal of an individual building.

Competencies

- Subject-specific Competencies: Concepts and Theories (fostered)
- Method-specific Competencies: Analytical Competencies (fostered)
- Social Competencies: Communication (fostered)
- Personal Competencies: Adaptability and Flexibility (fostered)

Literature

- Alois Riegls, Der moderne Denkmalkultus. Sein Wesen und seine Bedeutung, Wien/Leipzig 1903.

Abstract

In the seminar, selected texts on architectural theory and monument preservation are read together and discussed in plenary. The focus is on selected writings from John Ruskin, Gottfried Semper and Friedrich Nietzsche to Alois Riegl and Adolf Loos to Walter Benjamin, Aleida Assmann and Peter Zumthor.

Objective

Skills in reading complex theoretical and literary writings on architecture and monument preservation are taught. With increasing practice, these enable participants to undertake an independent appropriation of architectural theory and monument preservation content.

Content

The writings on architectural theory and historic preservation discussed in the seminar provide an overview of the most important theories and concepts of historic preservation. Ruskin’s narrative of architectural historicity, Semper’s conception of “Bekleidung” and Nietzsche’s transformation of mythology are covered, as are Riegls notions of “Erinnerungswert” and “Gegenwartswert”, Loos’ writings on architecture, Benjamin’s notion of aura and Aleida Assmann’s memory space as well as Peter Zumthor’s atmosphere. Each text is discussed in terms of textual structure, conceptual history, visual language, relationship to poetry and literature, strategies of theory, etc. Identifying the levels and intersections that link a theory with other theories characterises one of the main tasks of our seminar.

Competencies

- Subject-specific Competencies: Concepts and Theories (assessed)
- Method-specific Competencies: Analytical Competencies (assessed)
- Social Competencies: Communication (fostered)
- Personal Competencies: Adaptability and Flexibility (fostered)

Abstract

Heritage conservation is dedicated to the preservation and protection of historical buildings. In this lecture, students will learn about the theoretical positions on historic monuments and the basics of preservation in practice.

Objective

In addition to active participation in the discussions, students will be asked to engage with a topic or object of their own choice in order to be able to develop and comprehensively identify their own positions within the context of preservation. Our goal here is to foster students’ communication skills and the culture of discussion.

Content

The responsible reconstruction and further development of the existing building stock requires knowledge and an understanding of the theoretical positions conservation and the basics of preservation in practice. The core course of spring semester 2024 conveys this knowledge to students with the help of selected writings and discusses them in the context of various guest lectures.
**Literature**

**READING LIST**

**Monographs and edited volumes:**


Dehio, Georg, Kunsthistorische Aufsätze. München 1914


Franz, Birgit, Gerhard Vinken und Johanna Blokker (Hg.), Denkmal - Werte - Bewertung, Denkmalpflege im Spannungsfeld von Fachinstitution und bürgerschaftlichem Engagement, Holzminden 2013 (Veröffentlichung des Arbeitskreises Theorie und Lehre der Denkmalpflege e.V., Band 23).

Huse, Norbert (Hg.), Denkmalpflege: Deutsche Texte aus drei Jahrhunderten, München 1984.

ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


Petzet, Michael und Gert Mader (Hg.), Praktische Denkmalpflege, Stuttgart/ Berlin/ Köln 1993.


Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


Wohlleben, Marion und Georg Mörsch, Georg Dehio und Alois Riegl - Konservieren, nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

**Fundamentals and legal texts:**

Stadt Zürich Hochbaudepartement, Amt für Städtebau, Denkmalpflege und Archäologie (Hg.), Schulhäuser der Stadt Zürich. Spezialinventar Archäologie und Denkmalpflege, September 2008


**Denkmalpflegegesetzgebung in den Heimatkantonen der Kursteilnehmenden.**

**Die Kunstdenkmäler der Schweiz**

**INSA – Inventare der Heimatkantonen der Teilnehmenden**
The aim of the course is to familiarise students with the essential subject areas, the most important protagonists and lines of argumentation. The course provides an overview of theory formation in heritage conservation. The focus is on European history and German-language literature. The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a "monument", structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer’s (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zurich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.

### Literature

- Leo Schmidt, Einführung in die Denkmalpflege, Darmstadt 2006.
- Wolfgang Götz, Beiträge zur Vor- und Frühgeschichte der Denkmalpflege. Die Entwicklung der Denkmalpflege in Deutschland vor 1800 (Diss. Leipzig 1956), Zurich 1999 (Veröffentlichungen des Instituts für Denkmalpflege an der ETH Zürich, vol. 20).
- Gottfried Kiesow, Einführung in die Denkmalpflege, Darmstadt 1982.
- Gottfried Kiesow, Denkmalpflege. Texte zum Denkmalschutz und zur Denkmalpflege, Bonn 1996 (Schriftenreihe des Deutschen Nationalkomitees für Denkmalschutz, vol. 52).

### Prerequisites / notice

To follow

### Competencies

#### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

#### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: fostered
- Project Management: fostered

#### Social Competencies

- Communication: assessed
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: assessed

#### Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed

### Major Courses and Cooperations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>079-0150-00L</td>
<td>Preservation Law</td>
<td>O</td>
<td>2 credits</td>
<td>1G</td>
<td>S. Langenberg</td>
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<tr>
<td>Abstract</td>
<td>The course elaborates the legal concept of “monument” in its important distinction from the respective scientific concept. It highlights its embeddedness and effect in public building law. Furthermore, it deals with legal protection instruments and procedures.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>In addition to elaborating the legal concept of monuments, the course familiarises participants with legal protection instruments and procedures. It is planned to involve the participants by means of practical examples.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a “monument”, structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer’s (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zurich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.</td>
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</tbody>
</table>

| Number     | Theory and History of Preservation  | O    | 2 credits | 2V  | R. Rehm |
| Abstract   | The course provides an overview of theory formation in heritage conservation. The focus is on European history and German-language texts. |
| Objective  | The aim of the course is to familiarise students with the essential subject areas, the most important protagonists and lines of argumentation from antiquity to the 21st century, and to contrast the different approaches to thought and their development. |
| Content    | In order to get to know the formation of theory, its paths and detours, the most important terms and persons in the history of monument conservation are introduced. Based on various texts, the history of the protection of architectural monuments since antiquity is illustrated. Further focal points in the history of monument preservation were during the Enlightenment, the French Revolution and in the process of the formation of nation states. The discourse on the concept and practice of monument conservation as we understand it today was led by a number of conservators in the German-speaking world around 1900. War-related destruction and the incipient building boom in Europe led to modern debates on the theory of monuments, which are still relevant today. Dealing with monument values is not an end in itself; it can be essential for the preservation of the monument or for historical mediation. Critical positions on the tasks, goals or practices of heritage preservation can only be developed against the background of a knowledge of its historical approaches. |

### Literature

- Leo Schmidt, Einführung in die Denkmalpflege, Darmstadt 2006.
- Wolfgang Götz, Beiträge zur Vor- und Frühgeschichte der Denkmalpflege. Die Entwicklung der Denkmalpflege in Deutschland vor 1800 (Diss. Leipzig 1956), Zurich 1999 (Veröffentlichungen des Instituts für Denkmalpflege an der ETH Zürich, vol. 20).
- Gottfried Kiesow, Einführung in die Denkmalpflege, Darmstadt 1982.
- Gottfried Kiesow, Denkmalpflege. Texte zum Denkmalschutz und zur Denkmalpflege, Bonn 1996 (Schriftenreihe des Deutschen Nationalkomitees für Denkmalschutz, vol. 52).

### Prerequisites / notice

To follow

### Competencies

#### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

#### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: fostered
- Project Management: fostered

#### Social Competencies

- Communication: assessed
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: assessed

#### Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
Master Thesis Methods Seminar

### Abstract
The Methods Seminar provides students with assistance in identifying topics and writing initial project outlines for the master's thesis. Individual plenary sessions highlight methods and strategies for designing research papers. In individual meetings, students are guided in setting up their work plan as well as in drafting a preliminary outline of their MAS thesis.

### Objective
At the end of the semester, students will have significantly expanded their skills in scientific research, in writing project outlines, as well as their knowledge of scientific methods. The aim of the Seminar is the basic preparation for the following semester, in which the students are fully engaged in writing their master's theses.

### Prerequisites / notice
Die Lehrveranstaltung findet am Freitag von 14:00 bis 16:00 Uhr am Institut für Denkmalpflege und historische Baufororschung statt.

### Kursdaten:
- 22.9. HIL E 71.1
- 3.11. HIL E 71.1
- 1.12.
- 8.12.
- 15.12.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories

#### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

#### Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity

#### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Field of Future Heritage

#### Core Courses and Seminars

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<thead>
<tr>
<th>Number</th>
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<tr>
<td>079-0200-00L</td>
<td>Sustainable Development</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>S. Langenberg</td>
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<td></td>
<td><em>Does not take place this semester.</em></td>
<td></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>In the MAS/CAS seminar, we will critically discuss values and meanings relevant within the field of architecture. This will be done by examining and comparing the values of buildings as well as evaluation criteria of various actors – such as preservation authorities, architects, the real estate industry, or property owners.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<td></td>
<td>The students of this seminar will gain insight into different evaluation criteria and value systems within the larger field of preservation. Through various exercises, they learn to critically question current approaches to existing buildings, which are all too often characterized by demolition and replacement. The students will gain knowledge about lines of argumentation necessary to standing their ground in discussions with private or institutional clients. In addition to different assessment criteria for the preservation of historical monuments, they will learn the basics of life cycle analysis, calculation methods for determining grey energy and CO2 content, as well as the feasibility and usefulness of reuse and recycling of building materials.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>In the evaluation of the existing building stock, approaches vary substantially. While the institutional preservation of historical monuments is oriented towards a broad canon of values, architects evaluate these objects primarily according to shape and design, and more recently also according to resource-economic criteria. For the real estate industry, in turn, what seems to be decisive is primarily the market value (not only of the object, but of the building site above all), and for building owners it is the utility or resale value of a property. While buildings protected as monuments are widely recognized as cultural heritage, the large building stock of the second half of the 20th century is often considered unattractive and its maintenance or upgrading a costly imposition. However, it is precisely this stock that holds great potential, as it generally allows more possibilities for use and change than protected objects. In case of demolition, individual components of these buildings can possibly be reused. The discussion about values, protection and preservation of the existing building stock is complex and must be conducted on different levels. In addition to classic protection criteria, ecological and economic considerations, too, must be taken into account.</td>
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<tr>
<td></td>
<td><strong>Competencies</strong></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
|              | Concepts and Theories
|              | Analytical Competencies
|              | Decision-making
|              | Problem-solving
|              | Communication
|              | Sensitivity to Diversity
|              | Negotiation
|              | Adaptability and Flexibility
|              | Creative Thinking
|              | Critical Thinking

<table>
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<tr>
<th>079-0251-00L</th>
<th>Digital Heritage</th>
<th>O</th>
<th>3</th>
<th>2G</th>
<th>S. Langenberg</th>
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<td></td>
<td><em>Does not take place this semester.</em></td>
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</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>This course focuses on recent constructions built using innovative computational design and fabrication technologies, and the challenges associated with their repair, maintenance, and preservation.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>With the help of input lectures and excursions in and around Zurich, participants will explore new types of materials, structural designs, construction processes and methods associated with recently completed buildings built using computational methods. They will learn to critically observe existing theories and methods of preservation and discuss in groups the relationship between today’s digitally fabricated objects and future challenges in the discipline of preservation.</td>
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</tbody>
</table>
Content
The past two decades witnessed significant advances in the areas of computational design and digital fabrication in architecture. These advances include the use of advanced fabrication tools such as robotic arms and 3D printers which are computer-controlled via algorithmic scripts for the purpose of manufacturing geometrically complex building parts that are optimized in terms of materials and structural design. The prototypes and buildings which demonstrate such technologies often feature new and experimental composite materials, construction details, planning and fabrication processes. They are the result of unique interdisciplinary science and industry partnerships. The innovations embedded in such objects offer a preview to building methods which will become commonplace in the production of buildings in the future. As such, it is of critical importance to observe the performance of such novel constructions especially in terms of their durability and repairability, and to document the building processes to foresee the challenges associated with the preservation of the future building stock. Switzerland and especially Zurich has become an important innovation center in the field of digital fabrication in architecture. This course will discuss the role and relevance of digitally built architecture as heritage through excursions and input lectures. The discussion will be accompanied by a critical observation on the existing preservation theories and practices regarding innovations in architecture and construction.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>fostered</th>
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</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Analytical Competencies</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Communication</td>
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<tr>
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<td>Cooperation and Teamwork</td>
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</tr>
<tr>
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<td>Customer Orientation</td>
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Major Courses and Cooperations

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<thead>
<tr>
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<tr>
<td>079-0250-00L</td>
<td>Preservation in Switzerland</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>S. Langenberg</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>Historic buildings and sites are not per se significant parts of cultural heritage. They only become so when certain values are associated with them. Monument values are as dynamic as the society that produces them. The lecture traces the historical development of monument recognition and preservation in Switzerland since 1798.</td>
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<tr>
<td>Objective</td>
<td>Students will be able to name the most important actors in Swiss heritage conservation and describe developments in the field. They know methodological approaches and can place them in their historical context. They can identify the necessary principles and instruments in different situations and use them in their professional environment.</td>
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<tr>
<td>Content</td>
<td>In the 20th century, the most important impulses for the theory and practice of restoration came from the Federal Commission for the Preservation of Monuments, whose theoretical discourse and work are traced in detail. However, the activities of the cantons, private-law organisations and universities are also examined within the course. The institutionalisation of monument preservation is analysed in the context of social developments, whereby the evolution of its self-image from a patriotic civic duty in the age of industrialisation to monument preservation as environmental protection in the sustainability discourse of the 21st century is also examined. In the second half of the semester, the theoretical foundations, actors and instruments that are relevant in Switzerland today will be presented and their interaction explained.</td>
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<tr>
<td>Competencies</td>
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<tr>
<td>079-0252-00L</td>
<td>Development of the Existing Building Stock</td>
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<td>1G</td>
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<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>The course deals with the densification strategy of the city of Zurich and the resulting handling of existing building stock (mostly demolition and new construction). Insights into real estate evaluation and specific examples are used to show possible alternatives.</td>
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<tr>
<td>Objective</td>
<td>The course discusses the topic of densification and the future of the existing building stock. By dealing with the qualities of existing buildings within the areas to be densified, students are invited to discuss whether these objects are to be preserved, transformed, and supplemented or whether they have to be demolished.</td>
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<tr>
<td>Content</td>
<td>The city of Zurich introduced the densification strategy in the revised spatial planning law, focusing on the existing building stock. As a rule, densification is achieved today through demolitions and replacement. This includes buildings which are still in a good condition. The course thus aims to explore possible alternatives.</td>
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<td>Brief general introduction to the real estate market and real estate valuation; introduction to the topic of “densification”, well and badly realised examples; discussion of current densification projects and alternative solutions within the framework of two to three workshops.</td>
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Additional Core Courses and Seminars

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1628 of 2667
063-0901-00L  Construction History: The Construction Site and Its Technology

**Abstract**
History of the construction site and its technology

**Objective**
Introduction to Construction History and the so-called "building archeology": ability to perform a "close reading" of historic built fabric, based on in-depth knowledge on historic production techniques, both in the workshop and on the construction site itself. The focus is on constructions in stone.

**Content**
This lecture series deals with the history of the production of buildings. This history draws heavily on pictorial and archival sources, but the lecture will always establish the link to traces observable on site. In that sense, the lecture is an introduction to the wide topic of "building archeology". Among others, we will cover the following topics:

- construction materials, tools and tooling of construction elements
- material flow and economic boundary conditions of the construction site
- construction site technology and construction machinery (scaffolding, cranes, etc.)
- history of building production

The autumn semester is primarily dedicated to building with stone: from quarrying to dressing and lifting. We consider tools, construction site technology such as scaffolding, centring and other temporary works, cranes. We study all types of stone constructions, from foundations to walls to vaults, from concrete-like rubble stone through small dressed stone to huge monoliths.

The spring term lecture, conversely, is mostly dedicated to timber conservation and to the evolution of structural concepts over time.

**Lecture notes**
PDFs of the lecture slides will be provided before the lecture. Furthermore, the audience will be granted access to recent journal articles and book chapters providing in-depth insight into the topics covered by the lecture.

**Prerequisites / notice**
This lecture will NOT be given by Prof. Holzer in the fall term 2024 (sabbatical). Rather, students are asked to listen to the recordings from fall 2023 (video.ethz.ch) and to have a look at the slides from 2023. Both will provide all information necessary to pass the exam.

However, there will be biweekly lecture-hall events during which topics from last year's lecture will be considered, questions answered, and some additional illustrative examples presented. This will include presentations by PhD students reporting from their ongoing research projects.

**Competencies**

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
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<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
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<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
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<td>Project Management</td>
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**Additional Major Courses and Cooperations**

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</table>

**Abstract**
In addition to theory, heritage conservation also plays an important practical role in the current building revolution. In order to make the diverse possibilities in architecture visible, this course develops new strategies for communicating the discipline of monument preservation for an exhibition on this topic at S AM in 2025.

**Objective**
The aim of the seminar is to develop concepts for communicating and exhibiting heritage-related content and debates that go beyond specialist discourse and address a broader public. As part of the course, participants will acquire in-depth knowledge of various exhibition strategies in the field of architecture and will have the opportunity to develop exhibits for an exhibition organised by the S AM Swiss Architecture Museum (Basel) in collaboration with the Chair of Construction Heritage and Monument Preservation at ETH Zurich and ICOMOS Suisse in spring 2025.

**Content**
At a time when the maintenance of existing buildings is seen as an essential element of the building revolution, the theory and practice of heritage conservation is taking on an integral role. Nevertheless, heritage conservation still has to contend with image problems: people often misunderstand exactly what its aim is and, unaware of its mission, principles and (still highly topical) theories, the discipline is often assumed to have a purely conservative attitude. 50 years after the European Year of Monument Conservation in 1975, when the whole of Europe was dominated by the question of how to preserve the built heritage, there is no need for a fundamental repositioning, but there is certainly a need for an "update" on issues of monument conservation and its attitude in the face of current challenges. The joint exhibition at the S AM Swiss Architecture Museum in spring 2025 is dedicated to this topic. The course offers the opportunity to deal with architectural exhibition strategies and to participate in the development of various concepts for communicating the theory and practice of heritage conservation. New guiding principles for the future practice of heritage conservation will be jointly derived on the basis of best practice examples. In group work, current examples of successful cooperation between heritage conservation and architecture will be analyzed and documented for presentation in the exhibition in the form of drawings, texts and models. Depending on the number of participants, other parts of the exhibition can also be the subject of the work.

**Prerequisites / notice**
The course addresses primarily students of the MAS ETH in Denkmalpflege und Konstruktionsgeschichte and the CAS ETH in Future Heritage.
### Competencies

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### Building Surveying and Building Archaeology

**W 2 credits 2G**

**Does not take place this semester.**

**Abstract**
Surveying and measuring technologies in historical building archaeology. Case studies on building archaeology.

**Objective**
Basic understanding of different surveying methods and first practical contacts with technical surveys instruments. Understanding of the procedures and aims of building archaeology.

**Content**
From folding rule to laser scanner: surveying techniques and their possible applications.

The elective subject "Building Surveying and Building Archaeology" covers surveying and measurement methods ranging from simple hand measurements and tachymetry to laser scanning, terrestrial and drone-based photogrammetry (structure from motion) and other non-invasive assessment methods such as thermal imaging. The different methods and technologies will be presented on the basis of current or completed research projects and their practical applications will be discussed. Internal and external guest speakers will report on their latest research projects in the field of building research and construction history. In the course of the elective, students will also have the opportunity to try out the methods themselves and integrate them into a small concluding project of their own.

The course is composed of theoretical and practical parts in and outside the classroom.

**Literature**
Will be announced in the course for the individual lectures.

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**Immersion Week**

**O 2 credits 3G**

**Abstract**
Through joint reading seminars, visits, and lectures, current topics and concepts in preservation and construction heritage are discussed.

**Objective**
Students explore specific questions in depth and discuss them within the group and with experts.
Competencies

Subject-specific Competencies
- Concepts and Theories (assessed)
- Techniques and Technologies (assessed)

Method-specific Competencies
- Analytical Competencies (fostered)
- Decision-making (assessed)
- Media and Digital Technologies (fostered)
- Problem-solving (assessed)
- Project Management (fostered)

Social Competencies
- Communication (fostered)
- Cooperation and Teamwork (fostered)
- Self-presentation and Social Influence (fostered)
- Sensitivity to Diversity (fostered)
- Negotiation (fostered)

Personal Competencies
- Creative Thinking (assessed)
- Critical Thinking (assessed)
- Integrity and Work Ethics (fostered)
- Self-awareness and Self-reflection (fostered)
- Self-direction and Self-management (fostered)

Electives

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<th>Number</th>
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<td>Landscape Architecture I</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>A. Bucher</td>
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Abstract

The Landscape Architecture I and II lecture series looks at the design of nature from the first cultural landscapes to today's complex cultural landscape formations. The lecture series not only analyzes the results of anthropogenic nature design, but also discusses their various causes, contexts and consequences.

Objective

The course provides the basics and tools for an in-depth understanding of the discipline of landscape architecture and its far-reaching interconnections with architecture, urban planning, ecology and other spatial and nature-related sciences. The aim is to adopt landscape perspectives in planning and design processes and to critically reflect on one's own projects within a specific context.

Students learn about historical developments and their topicality and learn “from history”. Design contexts are presented on the basis of examples. Students develop a basis for ways of thinking and action for current landscape architectural challenges.

Content

The lectures in the fall semester course "History and Theory of Gardens and Landscape Architecture" provide an overview of the cultural history of nature, the landscape and the garden from its origins to the present day. An in-depth understanding of change as well as the design strategies and characteristics of the most important epochs and their current relevance will be discussed.

Lecture notes

Handouts and a bibliography will be provided

Literature

Handouts and a bibliography will be provided

Prerequisites / notice

General information on the examination:

Bachelor students: The knowledge taught in the lecture and the exam-relevant literature provided by the lecturer serve as the basis for exam preparation. The course is designed as an annual program. As the written session exam tests knowledge from both the Landscape Architecture I and II lecture series, it is strongly recommended that you attend the course over two semesters. The examination topics will be announced shortly before the end of the semester. The lecturer will provide texts on the examination topics as pdf files for download. These serve to deepen understanding of the lecture.

Mobility students or students from other departments: Students who only attend the lecture for one semester complete the lecture with an end-of-semester oral examination. Here too, the lecturer provides literature relevant to the examination as a download. Students registered for the exam will receive further information on the exam procedure by email shortly before the end of the semester.

Competencies

Subject-specific Competencies
- Concepts and Theories (assessed)
- Techniques and Technologies (fostered)

Method-specific Competencies
- Analytical Competencies (fostered)
- Decision-making (assessed)
- Media and Digital Technologies (fostered)
- Problem-solving (fostered)
- Project Management (fostered)

Social Competencies
- Communication (fostered)
- Cooperation and Teamwork (fostered)
- Leadership and Responsibility (fostered)
- Sensitivity to Diversity (assessed)
- Negotiation (fostered)

Personal Competencies
- Adaptability and Flexibility (fostered)
- Creative Thinking (assessed)
- Critical Thinking (assessed)
- Integrity and Work Ethics (fostered)
- Self-awareness and Self-reflection (fostered)
- Self-direction and Self-management (fostered)

052-0901-00L Building History I

Abstract

History of building from classical antiquity to modernity: building types, constructions, forms, with particular reference to functional issues such as flexibility of use, statics, durability. This is not a mere history lecture, but an important part of the basic introduction into construction.

Objective

Participants know the fundamentals of building history, including landmark monuments of each era, key historic constructions and forms. They are able to “read” a historic building and to relate it to building history. They are aware of the variety of historic building constructions.
Building history I covers the period from classical Greek antiquity to medieval architecture. The principal topics include construction issues such as Greek megalithic building, Roman mortar-and-rubble construction, and vaulting.

Within the Vitruvian and Albertian triad of firmitas, utilitas and venustas, we focus on the first two topics, whereas the last topic (deciphering the "meaning" of architecture) stands at the heart of the "architectural history" lectures. The present lecture contributes essentially to deepening knowledge about historic constructions, an indispensable precondition for building within existing fabric.

- buildings of Greek antiquity as examples of construction with huge stone blocks
- Roman buildings as examples of building with small materials, strict functional disposition, and evolution of the art of vaulting
- late antique and early Christian buildings: discovering interior space, developing new paradigms for religious architecture, construction wide-span roofs
- early and high medieval construction, continuing antique traditions, revival of dressed stone and vaulting
- small buildings, notably rural housing
- the medieval monastery

Lecture notes

Please keep a tight record of manuscript notes yourself. pdfs of lecture slides will be on line before each lecture. Lecture notes for exam preparation are provided and should be used in conjunction with the pictures from the lecture slides.

The exam will be held at the end of the first year. It is a computer-based multiple choice test. It calls for precise knowledge of the examples presented in the lecture, including the specifics of the architecture and construction of the buildings. Terminology is in GERMAN.

Literature

Will be announced during the lectures.

Prerequisites / notice

Due to professor Holzer's sabbatical, this lecture will be given by Dr. Jasmin Schäfer, in Fall Term 2024. However, the contents will be identical to the lecture delivered by professor Holzer in the Fall Term of 2023. This includes the topics, slides, lecture notes. Professor Holzer's lecture of Fall Term 2023 is available as a recording on video.ethz.ch. The lecture of Dr. Schäfer in Fall Term 2024 will NOT be recorded. Please refer to the recording of Fall Term 2023 under video.ethz.ch.

You may either listen to the fall 2023 recordings, to Dr. Schäfer's live lecture, or to both, to be prepared for the spring term of 2025 and the exam.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Method-specific Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Social Competencies

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- Assessed
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- Assessed

Personal Competencies

- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

- Assessed
- Fostered
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MAS in Preservation and Construction History - Key for Type

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<td>Eligible for credits and recommended</td>
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<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Z</td>
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Key for Hours

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<td>G</td>
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<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Digital Clinical Research

➤ Mandatory Modules

➤➤ Module Digital Clinical Trials

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<tr>
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<tr>
<td>395-0100-01L</td>
<td>The Power of Study Design</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>S. Goldhahn, A. Burden, D. Stekhoven, to be announced</td>
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<tr>
<td>395-0103-00L</td>
<td>Precision Medicine and AI</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>A. Fontecedro-Curioni, A. Ghosh, S. Modica</td>
</tr>
</tbody>
</table>

Abstract

Precision Medicine is a new approach in health care aiming to deliver personalized prevention and treatment for human diseases, by taking into account individual differences in lifestyle, environment, and biology.

Objective

After taking this course, participants will be able

- to describe the goal of precision medicine;
- to explain different next-generation sequencing technologies;
- to illustrate how to make good use of public biological/clinical repositories;
- to demonstrate basic concepts of big data and machine learning;
- to explain how to genotype biological samples for a genetic disease;
- to describe examples of complicated ethical or clinical situations in personalized medicine.

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<tr>
<td>395-0104-00L</td>
<td>Digital Measures</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>J. Goldhahn, I. Clay</td>
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</table>

Abstract

Participants will learn all necessary steps to establish new digital measures for their own clinical research. They will get a comprehensive understanding of this new emerging field, will discuss the newest guidelines with authors from international societies, will have a chance to interact with digital pioneers, and will be enabled to develop a concept for their individual digital measure.

Objective

The course enables participants to...

1. describe why new methods are needed to generate evidence.
2. describe how new (digital) methods for generating evidence are established.
3. explain how the concept of patient-centredness is applied in the development of new methods for evidence generation.
4. analyse sources of bias in basic research.
5. analyse the conditions for the development and validation of new evidence generation tools.
6. understand the framework for the development of new methods for evidence generation and to analyse the advantages and disadvantages of different approaches.
7. develop their own concept for a new digital measure.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

➤➤ Module Digital Health

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<th>Number</th>
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<tr>
<td>375-0003-00L</td>
<td>Designing a Digital Biomarker (Group Project 2)</td>
<td>O</td>
<td>4 credits</td>
<td>1G</td>
<td>M. Jovanova, T. Kowatsch</td>
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</table>

Abstract

The course introduces the concept of digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

Objective

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) can meet the health monitoring needs of the world's aging population and the ever-growing number of chronic patients. However, this premise is based on applying information and communication technologies that allow us to monitor patient data in many different ways. In this course, we will analyze systematic ways to collect data, review the most appropriate methods and applications in healthcare, discuss the main challenges, and apply the newly gained knowledge in a project.

The course has four learning objectives, i.e., to

1. understand the concept of digital biomarkers in general
2. understand the various application areas of digital biomarkers
3. to critically reflect and assess existing digital biomarkers
4. to understand how to design a digital biomarker

Content

The course will cover the following topics:

1. Introduction to digital biomarkers
2. Design of digital biomarker studies
3. Exploration and assessment of digital biomarker candidates
4. Digital biomarker project and critical reflection
Literature


Prerequisites / Notice

This module is assessed based on the participant's pass/fail status of the group project (including a presentation). The group project is ungraded.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

375-0004-00L Designing a Just-in-time Adaptive Intervention (Group Project 3)

4 credits 2G

M. K. Nißen, T. Kowatsch

Abstract

Today, we face the challenge of chronic conditions. Personal coaching approaches are neither scalable nor financially sustainable. The question arises therefore to which degree Digital Health Interventions (DHIs) are appropriate to address this challenge. In this CAS module, students will design, implement and evaluate a DHI, esp. a just-in-time adaptive intervention.

Objective

After this module, participants will be able to...

1. understand the importance of just-in-time adaptive interventions (JITAs), esp. for the prevention of NCDs
2. understand the design, implementation and evaluation of smartphone-based and chatbot-delivered JITAs
3. discuss opportunities and challenges of JITAs
“Can medical Alexas make us more healthy?” (The New York Times, April 2021); “Wearables as a tool for measuring therapeutic adherence in behavioral health” (npj Digital Medicine, May 2021); “Improving community healthcare screenings with smartphone-based AI technologies” (The Lancet Digital Health, May 2021); “Predictive analytics and tailored interventions improve clinical outcomes” (npj Digital Medicine, June 2021); “H1 2021 secured $14.7B in digital health funding, already surpassing all of 2020’s funding” (Rock Health, 2021)

What are the implications and rationale behind the recent developments in the field of digital health?

Digital Health is the use of information and communication technology for the prevention and treatment of diseases in the everyday life of individuals. It is thus linked to topics such as digital health interventions, digital biomarkers, digital coaches and healthcare chatbots, telemedicine, mobile and wearable computing, self-tracking, personalized medicine, connected health, smart homes, or smart cars.

In the 20th century, healthcare systems specialized in acute care. In the 21st century, we now face the challenge of dealing with the specific characteristics of non-communicable diseases (NCDs). NCDs are now responsible for around 70% of all deaths worldwide and 85% of all deaths in Europe and are associated with an estimated economic loss of $7 trillion between 2011 and 2025. NCDs are characterized in particular by the fact that they require an intervention paradigm that focuses on prevention and lifestyle change. Lifestyle (e.g., diet, physical activity, tobacco, or alcohol consumption) can reduce the risk of suffering from a chronic condition or, if already present, can reduce its burden. A corresponding change in lifestyle is, however, only implemented by a fraction of those affected, partly because of missing or inadequate interventions or health literacy, partly due to socio-cultural influences. Individual personal coaching of these individuals is neither scalable nor financially sustainable.

To this end, the question arises on how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, behavioral medicine, information systems research, and computer science, this CAS module has the objective to help participants interested in the multi-disciplinary field of digital health to better understand the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions (JITAIs).

After this module, participants will be able to...

1. understand the importance of JITAIs, esp. for the prevention of NCDs
2. understand the design, implementation and evaluation of smartphone-based and chatbot-delivered JITAIs
3. discuss opportunities and challenges of JITAIs

The CAS module is structured in two parts and follows the concept of a blended treatment consisting of live sessions and complementary online material. In the live sessions, participants will learn relevant topics. Complementary learning material (e.g., video clips), multiple-choice questions, and exercises are provided via the online learning platform.

In the second part, participants work in teams and will use their knowledge from the first part of the module to develop a smartphone-based and chatbot-delivered JTAI with MobileCoach (www.mobile-coach.eu), an open-source software platform for the development of digital biomarker and digital health interventions. Each team will then present and discuss the resulting JTAI and evaluation results with their colleagues who will provide peer reviews. Additional live coaching sessions are offered to support the teams with the design and evaluation of their JITAIs, and with the preparation of the final group project presentations.

References


Prerequisites / notice

This module is assessed based on the participant's pass/fail status of the group project (including a presentation). The group project is ungraded.

Compulsory Elective Modules
### Module Regulatory Thinking

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<th>Number</th>
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<tr>
<td>395-0200-00L</td>
<td>Regulatory World</td>
<td>W</td>
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<td>2G</td>
<td>J. Goldhahn, I. Clay, D. Schaffarczyk</td>
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</table>

**Abstract**
Participants will be introduced into regulations and landscape including all stakeholders. The different types of medicinal products are introduced including subsequent regulations. Participants apply the knowledge in different starting scenarios.

**Objective**
- understand the complexity of the regulatory landscape
- know the main characteristics of different medicinal products and subsequent regulatory pathways
- identify the different stakeholders and players in this landscape
- analyze different regulatory strategies using real-world cases
- The regulatory landscape – a challenge for all players
- Different types of medicinal products - different regulatory pathways
- Health authorities – friend or foe?
- Different countries – different regulations
- Successful regulatory strategy – make or break for a medicinal product
- From idea to product – do it yourself

**Content**
- The regulatory landscape – a challenge for all players
- Different types of medicinal products - different regulatory pathways
- Health authorities – friend or foe?
- Different countries – different regulations
- Successful regulatory strategy – make or break for a medicinal product
- From idea to product – do it yourself

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<td>395-0201-00L</td>
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<td>2 credits</td>
<td>4G</td>
<td>D. Schaffarczyk, R. Abächerli, further lecturers</td>
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</table>

**Abstract**
Students gain an overview of how to transform a research idea into a finished healthtech product by confidently navigating different regulatory landscapes and developing compelling certification strategies for various healthtech products. Students learn how to use Regulatory Thinking to turn Regulatory Affairs into a business planning tool.

**Objective**
- Applying of regulatory thinking and translation of this method into practice.
- Getting an overview of applicable laws, different regulations, directives and guidelines in the healthtech sector: MD, IVD, SaMD, medicine, biotech, ATMP.
- Understanding the different roles and responsibilities of Certification Bodies (CB), Notified Bodies (NB), and other Regulators and/or Reimbursement Agencies, hereafter: Competent Authorities (CAs).
- Knowing how to address CAs, including communication and interaction
- Awareness of the importance of a quality management system (QMS) and knowing different systems, including, but not limited to ISO 13485:2016, GMP, GLP, GCP

**Content**
The journey of regulatory thinking - from medical devices (MDs), to in vitro diagnostics (IVDs), to software as a medical device (SaMD), to medicines and advanced therapeutic medicinal products (ATMPs): Commonalities, differences and the search for the lowest common denominator in terms of:
- Regulations/Directives/Laws/Guidelines
- Interaction with the regulatory authorities
- The principles of safety/efficacy/performance/transparency
- The requirements for the implementation of a QMS

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<td>395-0202-00L</td>
<td>Intended Use / Indication</td>
<td>W</td>
<td>2 credits</td>
<td>4G</td>
<td>D. Schaffarczyk, R. Abächerli, further lecturers</td>
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</table>

**Abstract**
From software as a medical device to medicinal products: The intended use of a healthtech product serves as strategic pivotal point from conception to reimbursement strategies: Understanding its importance defines advertising claims and ensures that the product meets the needs of patients.

**Objective**
- Know and understand different definitions: medical need / public health assessment; personalized medicine, pharmacogenomics / customized device.
- Understand the importance of medical and stakeholder needs assessments in medicine / medtech / in vitro diagnostics / software as medical device / artificial intelligence and among different stakeholders.
- Understand the relationship between indication / intended use / intended purpose and development, including risk assessment.
- Define the intended use / intended purpose for a healthtech product and derive user groups, patient groups, indications and contraindications.
- Understand and derive an overview of the different stakeholders of a healthtech product and their different interests.

**Design and Development Plan, Clinical Development Plan: Plan development correctly.**

- Overview of different development models, starting with requirements engineering, the classical waterfall model and V-model up to agile methods for software as medical device or AI concepts.
- ISO 14971: Understanding and applying principles of risk management.
- IEC 62366: Understanding and applying the principles of usability engineering.
- Artificial Intelligence: Know the challenges of artificial intelligence in healthtech products, define an AI policy and develop a verification process.

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1636 of 2667
The intended use is the "linchpin" in the development, approval and reimbursement of medicinal products or medical devices: Whether software as a medical device, artificial intelligence in medical devices, but also in pharmaceuticals or biotechnology, the intended use is the first and last touchstone - alpha and omega - of all healthtech concepts.

- Intended use, user and patient groups I/III: How the intended use of a healthtech product influences its development, safety, performance, marketing strategy and reimbursement possibilities.

- Intended use, user and patient groups II/III: How the intended use of a healthtech product determines the patient population and thus defines indications and contraindications.

- Intended use, user and patient groups III/III: How the intended use of a healthtech product determines the requirements for different user groups.

- Software as a medical device or drug: What is the market missing - what does the patient want? Derive product re-quirements by understanding market requirements and pa-tient needs. (development planning).

- Software as a medical device or drug: Who is interested in the product, who benefits from it, who works with it? Derive concepts for usability and risk management by understanding-ig the different user groups and their interests (verification and validation).

- Software as a medical device: artificial intelligence, digital biomarkers, new biotech concepts: development and market-ing in compliance with regulations by applying "existing" standards to future technologies (regulatory compliance / legal compliance).

Module Nutrition in Medicine

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
395-0204-00L | Development Process: Preclinical | W | 2 credits | 4G | A. Krieg, L. Fischer

**Abstract**
An overview of the preclinical development of drugs as well as medical devices and in vitro diagnostics is given. The relevant regulations are conveyed in a practice-oriented manner.

**Objective**
- Understanding the principles and limitations of the preclinical efficacy and safety disciplines in product development - pharmacodynamics, pharmacokinetics and toxicology
- Understanding and applying regulations for drug development, development of medical devices and in vitro diagnostics
- Understanding for which purposes GLP (Good Laboratory Practice) is applied
- Understanding and applying the do's and don'ts of animal experiments in product development
- Understanding the different possibilities and the importance of communication with the regulatory authority in early product development

**Content**
The Module 4 "Development Process: Preclinical" includes an overview of preclinical efficacy and safety in drug development as well as in the development of medical devices and in vitro diagnostics. Emphasis will be placed on the applicable regulations and potential interactions with regulatory authorities in early product development. When a preclinical development plan becomes necessary and what is needed to start with will be explained in a practical way. An overview is also given of which preclinical studies and documents are required in order to be able to conduct an early clinical study in humans for the first time.

Module Individual Specialisation

One additional module may be chosen in agreement with the Programme Director.

Master's Thesis

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1637 of 2667
**Abstract**
The research project includes the study of existing literature, specification of the research question, choice of the methodological approach and/or study design, statistical considerations (if applicable), regulatory considerations, description about the data management and/or data collection, analysis and interpretation of data (if applicable), and the written and oral reporting of the findings.

**Objective**
The students shall demonstrate their ability to carry out a structured, scientific piece of work independently. Hereby they will be able to use digital tools and new study concepts independently and responsibly to conduct pragmatic and patient-centric clinical research.

**Content**
Students enrolled in the MAS ETH in digital Clinical Research programme who have acquired at least the minimum number of required credits from two CAS are eligible to write the Master's thesis. They will use the knowledge gained in the first two CAS of the MAS programme to design a clinical research project investigating a question within their area of interest.

The 20-weeks research project must have a digital component, such as the use of digital biomarkers or remote patient monitoring. It must also take into account regulatory considerations. If a student considers conducting a clinical trial in context with their Master’s thesis, they must prepare a complete protocol as well as the necessary regulatory documents. Other approaches to the research question are possible in consultation with the supervising professor. In general, the research project includes the study of existing literature, the specification of the research question, the choice of the methodological approach and/or study design, statistical considerations (if applicable), regulatory considerations, the description about the data management and/or data collection, the analysis and interpretation of data (if applicable), and the written and oral reporting of the findings.

**Prerequisites / notice**
two CAS completed

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### MAS in Digital Clinical Research - Key for Type

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### Key for Hours

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**ECTS**
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
MAS in Global Cooperation and Sustainable Development

The compulsory courses of NADEL are accessible only for students of the MAS in Global Cooperation and Sustainable Development and for qualified employees with at least two years experience in development cooperation and a Master's level or equivalent level of education as recognized by ETH. PhD students doing empirical research in development cooperation may be admitted "sur Dossier".

The elective courses are open to master students of the ETH with registration/ waiting list. MAS students do have priority.

► Programme Regulations 2021

★★ Advanced Training Courses

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<td>865-0024-00L</td>
<td>The SDGs in an Urbanising World</td>
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<td>specialists with at least 24 months of practical</td>
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<td>This course draws out good practices in promoting</td>
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<td>sustainability development at the city level.</td>
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<td>Participants gain insights on designing</td>
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<td>urban- focused development interventions.</td>
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<td>Historically, cities have been hubs of innovation,</td>
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<td>economic activity and rising prosperity.</td>
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<td>However, the unprecedented speed and scale at</td>
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<td>which cities are growing today is a huge</td>
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<td>challenge. As epicenters of migration,</td>
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<td>environmental degradation, health hazards and</td>
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<td>unemployment, urban areas are especially</td>
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<td>vulnerable to disasters, social conflict and</td>
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<td>inequality. Despite this, some of the most</td>
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<td>promising initiatives to achieve the SDGs</td>
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<td>have been implemented by cities. What strategies</td>
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<td>and processes do successful city- based initiatives</td>
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<td>mainstreaming the SDGs at the local level? What</td>
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<td>can be learnt from experiences so far? This</td>
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<td>sustainability and equity at the city and local</td>
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<td>level. Participants gain insights on designing</td>
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The course enables participants to understand the significance of the engagement of civil society organisations in policy processes in order to overcome exclusion and foster voice. The course acquaints participants with concepts and practice of civil society participation in shaping policies at micro and macro level and provides practical tools for influencing political processes.

**Content**
- The qualitative research approach.
- Qualitative research methods, including interviews, focus group discussions and participant observation.
- Designing and planning qualitative studies.
- Qualitative data analysis and interpretation.
- Reporting of qualitative results.
- Embedding qualitative research within a project cycle.

**Prerequisites / notice**
Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with the NADEL secretariat.

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Critical Thinking

**865-0004-00L Qualitative and Participatory Research Methods for Development Practitioners**

*W* 1 credit 2G

**Abstract**
Qualitative research has much to offer to the practical work of development organizations. This course will provide an overview of the principles and practice of qualitative research and illustrate ways in which qualitative research can be incorporated into the programme cycle. Participants will learn to collect and analyse data, using qualitative methods.

**Objective**
The course aims to demystify qualitative research and build the skills of development practitioners in using qualitative methods confidently, and to communicate findings to different audiences.

**Content**
- The qualitative research approach.
- Qualitative research methods, including interviews, focus group discussions and participant observation.
- Designing and planning qualitative studies.
- Qualitative data analysis and interpretation.
- Reporting of qualitative results.
- Embedding qualitative research within a project cycle.

**865-0002-00L Migration and Development**

*W* 1 credit 2G

**Abstract**
Globally, over 280 million people live outside their countries of origin. While the concept of migration has negative connotations for some, migration can bring significant benefits – to both countries of origin and destination, if the right policies and initiatives are in place. The course explores the role that international cooperation can play in promoting the positive aspects of migration.
Objective
Course participants have improved understanding of the following issues:
- Definition of migration concepts and terms
- international legal frameworks related to migration
- The geography of migration flows
- Major drivers of migration
- The evolving concept of "migration and development"
- International cooperation organisations and their strategies and activities in terms of migration and development.

Content
Globally, over 280 million people are currently living outside their countries of origin, voluntarily and involuntarily; and a further 60 million people live in internal displacement settings within their countries of origin. Migration is multifaceted, and driven by various, often interlinked factors including conflict and violence, economic, social and political factors, as well as environmental and climate related events.

While the concept of migration has negative connotations for some, migration can bring significant benefits – to both countries of origin and destination, if the right policies and initiatives are in place. The course explores the role that international cooperation can play in promoting the positive aspects of migration and in reducing the potential negative consequences.

This course covers:
- important terms and concepts related to migration;
- international legal frameworks related to migration;
- the geography of migration flows;
- major drivers of migration;
- the evolving concept of migration and development;
- actions, strategies and initiatives of international cooperation actors when it comes to migration and development.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Cooperation and Teamwork
- Critical Thinking

Method-specific Competencies
- Project Management

Social Competencies
- Fostered

Personal Competencies
- Assessed

865-0100-01L Planning and Monitoring of Projects
W 1 credit 2G

Course participants have improved understanding of the following issues:

- Short intro to project evaluation, including main types, concepts and processes
- Intro to project monitoring, including the development of a monitoring and evaluation plan with indicators in order to assess project progress and steering
- Short intro to project evaluation, including main types, concepts and processes

Registration only through the NADEL administration office.

Abstract
The course provides a deeper understanding of the conceptual and methodological foundations of results-oriented Project cycle management, focusing on planning, monitoring and steering development projects.

Objective
The course participants prepare for their project assignments through improving their knowledge and skills related to selected aspects of project management.

Content
- Overview of key concepts and phases of project cycle management
- Intro to project planning, including the Logical Framework Approach, results chain and logframe matrix
- Intro to project monitoring, including the development of a monitoring and evaluation plan with indicators in order to assess project progress and steering
- Short intro to project evaluation, including main types, concepts and processes

Prerequisites / notice
Students of the course must fulfill requirements specified on the homepage of NADEL.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Project Management

Social Competencies
- Assessed

Method-specific Competencies
- Assessed

Personal Competencies
- Fostered

865-0020-00L Social Entrepreneurship – Driving Sustainability in Business
W 1 credit 1G

Does not take place this semester.

Only for MAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

Definition of social entrepreneurship and the difference with “entrepreneurship”
- Get inspired by concrete examples of successful social ventures
- Formulate a social business plan using the business canvas methodology
- Learning to think and act like a social entrepreneur
- The art and power of storytelling in an entrepreneurial context

Registration only through the NADEL administration office.

Abstract
This course introduces the concept of social entrepreneurship, understanding in which situations and under which conditions the concept can be applied, and the basics of developing a business strategy for a social enterprise.

Objective
This course introduces the concept of social entrepreneurship over three different blocks. The first part is dedicated to the definition, history, context and the successes and blockers of social entrepreneurship, including some real-world examples. In the second part the participants will learn to transform a social business idea into a concrete social business plan. The last block of the course is dedicated to the power of storytelling, where participants learn how to pitch their business ideas convincingly.

Content
- Definitions of “social entrepreneurship” and the difference with “entrepreneurship”
- Get inspired by concrete examples of successful social ventures
- Formulate a social business plan using the business canvas methodology
- Learning to think and act like a social entrepreneur
- The art and power of storytelling in an entrepreneurial context

Competencies
Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Decision-making

Social Competencies
- Customer Orientation

865-0001-00L Social and Cultural Aspects of International Development Cooperation
O 2 credits 3G M. Malefakis

Does not take place this semester.

Only for students in MAS Global Cooperation and Sustainable Development

Abstract
In this course, social and cultural dynamics of international development cooperation are analysed, discussed, and connected to contemporary development cooperation activities and projects. Themes to be focused on include the impacts of colonisation in development cooperation, decolonisation, migration, gender, racism, and education.
Objective
The learning goal is for students to critically reflect on the influences of these themes on the design and implementation of development cooperation interventions, as well as:
- display basic knowledge of selected topics on social and cultural aspects of development cooperation
- consider which social, cultural and psychological factors influence human action, and discuss their importance for development cooperation
- explain different conceptions of development in western and non-western cultures and indicate possible consequences for development projects

Content
Raising awareness on selected cultural and social aspects of development issues and their relevance for international development cooperation (DC):
- The importance of the concept of "culture" in DC
- Slavery, colonialism and decolonisation, and their historical and contemporary relics in DC (racism, white saviour complex, discrimination, white superiority, and so on).
- The impacts of social and cultural dynamics on DC
- The role of religion in development projects and interventions
- The challenges and opportunities of migration in DC
- Cross-cutting issues in DC: gender, localisation, and others

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

865-0010-00L
Politics and Governance
Objective
The course introduces the basics of politics and political economy and applies the theory to selected policy areas.

Competencies
Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

865-0007-00L
History and Forms of International Cooperation
Objective
The course introduces the basics of politics and political economy and applies the theory to selected policy areas.

Competencies
Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

865-0011-01L
Water, Sanitation and Waste Management
Objective
Interested students can apply to be placed on the waiting list and will be informed about a possible admission by the program coordinators within the first week after the start of lectures.

Abstract
The course provides an overview of the links among sanitation, water supply, waste management and environmental and health aspects. It gives an understanding of the specific challenges and possible solutions in ensuring environmental services and illustrates their impact on the population and settlements.
The participants are able to
- present the global situation and development trends in the sector of sanitation, water supply, waste management and for its main actors;
- discuss the relationships between water supply, sanitation and health;
- explain the principles of technologies for drinking water treatment, the management of sewage and waste, as well as appraise their strengths and weaknesses;
- explain which sustainable concepts are implemented and how they can be inserted into the technical, institutional and social structures so that they are economically, ecologically and socially sustainable;
- provide information where good professional resources are available.

**Environment, Natural Resources and Climate Change**

**Only for MAS in Global Cooperation and Sustainable Development**

**Abstract**
Degradation of the environment and non-sustainable use of natural resources, including land, water, forests and biodiversity is threatening individual livelihoods as well as local, national and international economies. This lecture series will address conflicts related to unsustainable resource use and discuss trade-offs between environmental sustainability and economic development.

**Objective**

The student will be able to
- describe the current status and threats of natural resource use and environmental degradation
- portray the management of natural resources such as land, forest, water, and biodiversity in different contexts and discuss the key challenges in each sector
- examine the implications of climate change on development and the sustainable management of natural resources
- analyze conflicts and trade-offs between natural resource use and economic development
- discuss the global priorities relating to human-induced changes to the environment, and how these can be met

**Competencies**

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**Development Economics**

**Only for MAS in Global Cooperation and Sustainable Development**

**Abstract**
This course is an introduction to theoretical and empirical discussions on economic development, with a focus on the challenges of developing countries over the last 50 years. The course provides answers to the following questions: How can and should development be measured? What factors drive economic growth and contribute to poverty reduction?

**Objective**

Students are able to
- critically discuss economic questions in the context of developing countries
- critically discuss policy recommendations for economic development

**Content**
- measurement of development, poverty and inequality,
- growth theories
- trade and development
- education, health, population and development
- states and institutions
- economic policies for economic growth and poverty reduction
- economics of development aid

**Agriculture, Food and Nutrition Security**

**MAS ETH in Global Cooperation and Sustainable Development**

**Abstract**
Food security has been on top of the policy agenda for decades, but still a considerable proportion of the population in developing countries remains hungry and poorly nourished. This lecture series will explore how we produce and distribute food; it analyses the concept of food and nutrition security and discusses ways and means for measuring and achieving it in low-income countries.

**Objective**

The student will be able to
- describe the most important milestones in the history of food and agriculture
- understand the concept of food and nutrition security, and discuss it's impact and causes
- compare different approaches to promote and increase crop- and livestock production in a sustainable manner
- reflect on some of the main economic challenges of the world food system and understand some of the trade-offs between smallholders' decisions of labor, consumption, and production of food
- give insights on how international organizations work with farmers and governments in low income countries

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
</tr>
</tbody>
</table>

**Health and Development**

**MAS ETH in Global Cooperation and Sustainable Development**

**Abstract**
The following topics will be discussed: Basic principles of epidemiology and global burden of disease distribution, Health systems and health system strengthening including economic aspects and health insurance, communicable diseases such as HIV/AIDS, Malaria, tuberculosis and neglected tropical diseases, mother and child health, non-communicable diseases and transition in health in LAMICs.

**Objective**

This course aims at providing a public health driven overview on most important topics related to health and health care in low- and middle-income countries (LAMICs). After the module participants shall have broad understanding of challenges for health, health care and health systems in LAMICs. They shall be able to discuss more in depth some major global health topics, such as health systems, transition in health, malaria, neglected tropical diseases and HIV/AIDS. The course will provide an insight into current strategies and approaches addressing major global health topics.

**Policy Impact Analysis**

**MAS ETH in Global Cooperation and Sustainable Development**

**Abstract**
Interested students can apply to be placed on the waiting list and will be informed about a possible admission by the program coordinators within the first week after the start of lectures.

**Objective**

The interested students will be able to
- give policy analysis of the impact of health and development policies on individual livelihoods as well as local, national and international economies.
- critically discuss policy recommendations for economic development
- explain which sustainable concepts are implemented and how they can be inserted into the technical, institutional and social structures so that they are economically, ecologically and socially sustainable;
- provide information where good professional resources are available.
Abstract
This course introduces students to key methods for quantitative policy impact analysis and covers the different stages of the process. Acquired skills are applied on a real project from a development organization. Students also learn how to perform simple statistical analyses with the statistical Software R.

Objective
- Know strategies to test causal hypotheses using experimental methods and regression analysis.
- Are able to formulate and implement a research design for a particular policy question and a particular type of data.
- Are able to critically read and assess published studies on policy evaluation.
- Are able to use the statistical software R for simple data analysis.
- Can apply all the steps involved in a policy impact evaluation.

Content
Policy impact evaluation employs a wide variety of research methods, such as statistical analysis of secondary data, surveys or laboratory and field experiments. The course will begin with an overview of the various methodological approaches, including their advantages and disadvantages and the conditions under which their use is appropriate. It will continue with a discussion of the different stages of a policy impact evaluation, including hypothesis generation, formulating a research design, measurement, sampling, data collection and data analysis. For data analysis, linear regression models will be revised, with a focus on difference-in-difference methods and randomized controlled trials used for policy evaluation. Students, who already have a solid background in these methods can skip these sessions.

Competencies
Throughout the course, students will work on the design of a policy impact evaluation for a real-world project.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>fostered</td>
<td>assessed</td>
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<td></td>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<td>assessed</td>
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<td>Analysis</td>
<td>Problem-solving</td>
<td>Sensitivity to Diversity</td>
<td>Critical Thinking</td>
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<td>fostered</td>
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<td>Project Management</td>
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<td>Negotiation</td>
<td>Self-direction and Self-management</td>
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<td>fostered</td>
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<td>fostered</td>
<td>fostered</td>
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</table>

865-0012-00L Gender and Economics
Only for MAS/CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

ETH MA/MSc students apply with a letter of motivation to the NADEL administration office.

Abstract
This course on gender and economics is intended to provide basic- and intermediate-level training to development practitioners and policy and program staff in international development agencies.

Objective
The overall objective of the course is to strengthen the capacity of technical advisors and program staff on the importance of gender-responsive economic policy. The course conveys basic knowledge about genders aspects in economics. Key elements are:
- Feminist approaches to macroeconomics, microeconomics and international economics
- Critical analysis of global and regional economic trends, including those related to economic crises
- Gender-responsive economic policy for program implementation, policymaking, and advocacy

Content
Economic inequalities between men and women persist in many countries. For example, in many countries, men earn more money and are more likely to own land and control productive assets than women. This course on gender and economics is intended to provide basic- and intermediate-level training to development practitioners and program staff in international development agencies. The overall objective of the course is to strengthen the capacity of technical advisors and program staff on the importance of gender-responsive economic policy. The course is taught in cooperation with SDC and UN women.

865-0059-00L Storytelling for Systems Change
Only for CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

Registration only through the NADEL administration office.

Abstract
This course provides a foundation in the principles, techniques, and strategies for storytelling in the context of systems change. Key topics include:
- Psychology of Stories
- Key Elements and Techniques of Storytelling
- Ethics & Authenticity
- Using Stories in Project Cycle Management

Objective
By the end of this course, participants will be able to apply and adapt the fundamentals of storytelling to support their work as development practitioners and as proponents of systems change. They will be able to integrate storytelling techniques into activities such as reporting, fundraising, and context analysis. They will be better equipped to construct stories that are engaging and illustrative of the complexity of systems change.
**Competencies**

### Subject-specific Competencies
- Concepts and Theories assessed
- Communication assessed
- Self-presentation and Social Influence fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered

### Social Competencies
- Communication assessed
- Self-presentation and Social Influence fostered

### Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered

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**865-0049-00L AI for Global Development Organisations**

*Only for CAS in Global Cooperation and Sustainable Development students, as well as specialists with at least 24 months of practical experience in international cooperation.*

ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

*Registration only through the NADEL administration office.*

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### Project Assignment

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>865-0800-00L</td>
<td>Project Assignment</td>
<td>O</td>
<td>25</td>
<td>45P</td>
<td>external organisers</td>
</tr>
</tbody>
</table>

**Abstract**

MAS ETH D&C students complete project assignments at renowned organizations in international cooperation. The goal is to get to know the complex working reality of the modern development cooperation on site, and to gain relevant work experience. The assignment has a performance component and a learning component.

The duration of the project assignment is between 8 and 10 months.

- Apply knowledge acquired during the semester to a specific project setting
- Get to know the complex interdisciplinary and intercultural working reality
- Gain experience in project-based collaboration with different social stakeholders
- Gain professional experience in international cooperation

**Prerequisites / notice**

For the implementation of these project assignments NADEL is cooperating with some 30 governmental and non-governmental development organizations. Preconditions for the start are the successful completion of the study semester, adequate language skills (en; fr; es; depending on the country of assignment) and the medical suitability. The costs are financed through a scholarship from the Swiss Agency for Development and Cooperation (SDC).

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### Policy Essay

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>865-0900-00L</td>
<td>Policy Essay</td>
<td>O</td>
<td>6</td>
<td>13D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

For the final thesis, students choose a development policy topic in the context of their practical work. The focus is on the “critical reflection” of a freely chosen question.

- Recognize policy issues relevant to development in the own working context
- Identify the peculiarity and implications of a development policy issue for different stakeholder groups
- Work on a question from a scientific perspective
- Develop policy options for addressing an identified issue

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### Semester Thesis

*Only for MAS ETH in Global Cooperation and Sustainable Development*

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>865-0700-00L</td>
<td>Semester Thesis</td>
<td>O</td>
<td>4</td>
<td>9A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

**Abstract**

The students work on a question in multidisciplinary groups applying theory-based approaches and sound methods. The results are discussed with experts and policymakers. The thesis is a literature study with a strong application-oriented or empirical character based on scientific publications, expert opinions and reports from organizations. The work may also include limited information surveys.

- Practice scientific collaboration in a multidisciplinary team
- Apply themselves to a development topic in order to address policy relevant questions
- Present and discuss study results and policy implications in front of different audiences

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### Programme Regulations 2024

#### Core Courses

#### Electives

#### Written Papers

#### Modules

#### Project Assignment

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**MAS in Global Cooperation and Sustainable Development - Key for Type**

<table>
<thead>
<tr>
<th>Type</th>
<th>Compulsory</th>
<th>Eligible for credits and recommended</th>
<th>Eligible for credits</th>
<th>Recommended, not eligible for credits</th>
<th>Courses outside the curriculum</th>
<th>Suitable for doctorate</th>
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<td>O</td>
<td>E-</td>
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<td>W+</td>
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<td>Dr</td>
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**Key for Hours**

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real-world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

<table>
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<tr>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Puhan, R. Heusser</td>
</tr>
<tr>
<td>Abstract</td>
<td>The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.</td>
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<td>Objective</td>
<td>The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.</td>
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<td>Content</td>
<td>The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real-world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td></td>
<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Personal Competencies</td>
<td>Cooperation and Teamwork</td>
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<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</tr>
<tr>
<td>752-2307-00L</td>
<td>Nutritional Aspects of Food Composition and Processing</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>B. E. Baumer, J. M. Sych</td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.</td>
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<tr>
<td>Objective</td>
<td>Students should be able to - describe and compare the major concepts/criteria used for the evaluation of the nutritional quality of food - apply these criteria when assessing the effects of selected processing techniques on nutritional quality. - evaluate recent formulation strategies aimed to achieve additional physiological benefits for targeted population groups (i.e. functional foods).</td>
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<tr>
<td>Content</td>
<td>The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, separation and emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>752-6301-00L</td>
<td>Nutrition-Related Physiology</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>F. von Meyenn, E. Gasser</td>
</tr>
<tr>
<td>Abstract</td>
<td>Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand.</td>
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<tr>
<td>Objective</td>
<td>Some basic knowledge in physiology is recommended for this course, which revisits important physiological topics, emphasizing their relation to nutrition. The aim is to give the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand. For students with a background in medicine, pharmacy or biology, the course is useful as a review of previously acquired knowledge. Major topics are basic neuroanatomy and neurophysiology; general endocrinology; the physiology of taste and smell; nutrient digestion and absorption; intermediary metabolism and energy homeostasis; and some aspects of cardiovascular physiology and water balance.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts for each lecture will be uploaded to Moodle every week.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Analytical Competencies</td>
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<td></td>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>fostered</td>
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</tr>
<tr>
<td>766-6205-00L</td>
<td>Nutrient Analysis in Foods</td>
<td>W+</td>
<td>3 credits</td>
<td>3U</td>
<td>to be announced</td>
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<tr>
<td>Does not take place this semester. Number of participants limited to 16.</td>
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<tr>
<td>Permission from lecturers required for all students.</td>
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<tr>
<td>In this practical course, different meals are prepared and then analysed for nutritional content in the laboratory. Based on these results, the nutritional value of each meal is critically evaluated and discussed, and the students must design a reformulated meal that has a superior nutritional content, justifying their choices.</td>
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<tr>
<td>The objectives of this practical course include learning about and having experience with analytical methods to determine micronutrient and phytonutrient content in foods, critical evaluation of analytical results, critical comparison with values from food composition tables, interpretation in relation to nutritional value of meals, and creative skills in the design a new meal.</td>
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</table>
The practical course Nutrient Analysis in Foods includes meal preparation (a half day in late 2023; date to be defined) and chemical analysis of four meals from four different types of diets (students will work in groups; one meal per group). The content of specific micronutrients and secondary phytonutrients (polyphenols and phytic acid) are analysed using common analytical methods. The analytical results are compared with calculated data from food composition databases using nutrition software and then critically evaluated.

There are no prerequisites to attend this course, however, students must be available to attend on all days of the course, including the oral presentation and colloquium. Attendance is compulsory.

Performance will be assessed by means of:
1) Contribution to laboratory practical work (29 Jan to 7 Feb 2024);
2) A written test on course content (via Moodle, completed by 9 Feb 2024);
3) A 15 min oral presentation of laboratory results in a seminar with colloquium (active discussion) (on 9 Feb 2024);
4) A (max) 8-page written report per group (deadline 16 Feb 2024).

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

The course is designed to provide fundamental tools and concepts in human nutrition research, including topics such as study design, statistical analysis, scientific writing and communicating results. Preparation of a research proposal will consolidate student learning. The course is designed for MAS and first semester MSc Nutrition and Health students.

Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples. It is a course for people interested in nutrition with a focus on concepts and principles of nutrition before, during and after exercise.

The course introduces basic concepts of the interaction between nutrition and exercise performance. It is a course for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

On completion of this course, students will have improved:
- Proficiency in retrieval and interpretation of scientific literature
- Ability to report scientific results in writing and orally
- Understanding of basic statistics and analytical skills used in preparing and reporting research, including in tables and graphs
- Understanding of experimental study design in basic and clinical research
- Familiarity with the research process and methods used in human nutrition
- Ability to report scientific results in writing and orally
- Skills in scientific writing and an understanding of the publication process
- Proficiency in retrieval and interpretation of scientific literature

Students are expected to attend and actively participate in the course, which includes the preparation of a research protocol that will be presented and graded during a poster presentation at the end of the semester.
## Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products. Students will be able... - to describe heuristics that influence consumer behavior in the food domain - to explain the consumer led food product development - to summarise how consumers perceive the environmental impact and the healthiness of foods - to assess the cultural, the environmental and the food policy impact on consumer behavior - to explain psychological factors influencing eating behavior.</td>
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<tr>
<td>Objective</td>
<td>Competencies Subject-specific Competencies</td>
<td>Concepts and Theories assessed</td>
<td>Methods-specific Competencies</td>
<td>Problem-solving assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication fostered</td>
<td>Customer Orientation assessed</td>
<td>Sensitivity to Diversity assessed</td>
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<tr>
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<td>752-0801-00L</td>
<td>Food Law and Legislation</td>
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<td>K. Krell Zbinden, E. Zbinden Kaessner</td>
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<tr>
<td>Abstract</td>
<td>Introduction to the principles of the EU and international organisations, Set up and Application of the Swiss Food Law. Knowledge of the principles and the structure of the EU in general and in the area of food safety, overview of the relevant bilateral agreements CH-EU as well as on the most important international organisations. Basic knowledge of the structure of Swiss food law and its implementation in the context of self-controll in food companies. The process of food enforcement is known and issues can be assessed from a legal perspective. General introduction into the EU and in the area of food safety (regulation on food safety), legislative procedures in the EU, introduction into the relevant bilateral agreements CH-EU, introduction into international organisations, general principles of the Swiss food law and the most important regulations as well as the most important legal procedures, legal settlement and the duties and responsibilities of the Food control authorities.</td>
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<tr>
<td>Objective</td>
<td>Competencies Subject-specific Competencies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork fostered</td>
<td>Sensitivity to Diversity fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking fostered</td>
<td>Self-awareness and Self-reflection fostered</td>
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<tr>
<td>551-0317-00L</td>
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<td>M. Kopf, A. Oxenius</td>
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<td>Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.</td>
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<td>Objective</td>
<td>Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.</td>
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<tr>
<td>Content</td>
<td>- Introduction and historical background - Innate and adaptive immunity, Cells and organs of the immune system - B cells and antibodies - Generation of diversity - Antigen presentation and Major Histoincompatibility (MHC) antigens - Thymus and T cell selection - Autoimmunity - Cytotoxic T cells and NK cells - Th1 and Th2 cells, regulatory T cells - Allergies - Hypersensitivities - Vaccines, immune-therapeutic interventions</td>
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<tr>
<td>Lecture notes</td>
<td>Electronic access to the documentation will be provided. The link can be found at &quot;Lernmaterialien&quot;</td>
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<td>Literature</td>
<td>- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020</td>
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<tr>
<td>Prerequisites / notice</td>
<td>For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a &quot;Sessionsprüfung&quot;. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.</td>
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### Competencies

<table>
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<tr>
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<th>Concepts and Theories</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>fostered</td>
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<td>Decision-making</td>
<td>fostered</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
<td>fostered</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td>Self-direction and Self-management</td>
<td>fostered</td>
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</table>

### Public Health Concepts

**752-6151-00L**

**Abstract**

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

**Objective**

At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

**Content**

Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition).

**Lecture notes**

Handouts are provided to students in the classroom.

### Essentials in Translational Science

**376-0300-00L**

**Abstract**

Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people (e.g. Medicines). The course should help to clarify basics of translational science, illustrate successful applications and enable students to integrate key features into their future projects.

**Objective**

After completing this course, students will be able to understand:
- Principles of translational science including medical device development, intellectual property, regulatory environment and project management
- Students should be able to apply this knowledge in drug development programs in Pharma, Biotech or their own spin-off.

**Content**

What is translational science and what is it not including:
- How to identify need?
- How to choose the appropriate research type and methodology
- How to measure success?
- How are medical devices developed?
- How to handle IP in the development process?
- How does the regulatory environment impact innovation?
- How to manage complex development projects?

Positive and negative examples will be illustrated by distinguished guest speakers.

**Literature**

Principles of Biomedical Sciences and Industry

Translating Ideas into Treatments

https://doi.org/10.1002/9783527824014

**Prerequisites / notice**

4x online input lecture followed by case preparation and symposium

### Critical Appraisal of Evidence for Exercise in Health and Disease

**376-0225-00L**

**Abstract**

This course will discuss the mechanisms and latest evidence-based recommendations of physical activity and exercise for a series of conditions and populations.

In the second part of each lecture session, published randomized controlled trials of the respective lecture’s topic will be discussed and critically appraised based on established tools.
Objective

On completion of this course students will be able to:
1. understand the role of physical activity and sedentary behavior in the maintenance of health and the etiology, prevention and treatment of disease
2. synthesize effective physical activity and exercise interventions for the prevention and management of several diseases and populations
3. evaluate recent evidence regarding physical activity and exercise interventions

Content

New trends in physical activity for prevention and rehabilitation
Introduction to critical appraisal tools
Exercise for Cancer Rehabilitation
Exercise for Musculoskeletal Rehabilitation (Focus on Osteoarthritis and Low Back Pain)
Exercise in Parkinson’s disease
Exercise for Rehabilitation of Metabolic Disorders (Focus on Obesity and Diabetes type 2)
Exercise for age-related diseases and disorders, Part A (Focus on Frailty and Falls)
Exercise for Stroke Rehabilitation
Exercise in Dementia and Mild Cognitive Impairment
Exercise for Children’s Rehabilitation (focus on Cerebral Palsy)
Exercise for age-related diseases and disorders, Part B (Focus on Sarcopenia and Osteoporosis)
Exercise in Multiple Sclerosis
Exercise for Cardiovascular Rehabilitation (Focus on Heart Failure)

Literature


Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies fostered

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making fostered
- Problem-solving fostered

Personal Competencies
- Critical Thinking assessed
- Integrity and Work Ethics fostered

Master’s Thesis

Number Title Type ECTS Hours Lecturers
766-6500-00L MAS Master’s Thesis O 20 credits 43D Lecturers

Abstract
The study program is completed with the Master thesis, an independent scientific work. Topics are selected within the domains of the MAS program. The work is supervised by a lecturer of the MAS program.

Objective
The Master thesis must demonstrate the student’s ability to independent, structured and scientific working.

MAS in Nutrition and Health - Key for Type

Key for Hours

| V | lecture                  | P | practical/laboratory course |
| G | lecture with exercise   | A | independent project        |
| U | exercise                | D | diploma thesis             |
| S | seminar                 | R | revision course / private study |
| K | colloquium              |   |                            |

Key for Hours

V lecture
G lecture with exercise
U exercise
S seminar
K colloquium

Special students and auditors need special permission from the lecturers.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1651 of 2667
MAS in Fire Safety Engineering

Four-semester, part-time MAS programme, starting in autumn semester (even years).

Next start: Autumn Semester 2024

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>121-0100-00L</td>
<td>Module 1: Fire Science ■</td>
<td>O</td>
<td>10</td>
<td>9G</td>
<td>A. Frangi, P. Jenny, M. Klippel, B. Merci, M. Siemon</td>
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<tr>
<td>121-0130-00L</td>
<td>Module 4: Structural Fire Design ■</td>
<td>O</td>
<td>10</td>
<td>9G</td>
<td>A. Frangi</td>
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</tbody>
</table>

Module 4: Structural Fire Design ■

Does not take place this semester.

MAS in Fire Safety Engineering - Key for Type

| O          | Compulsory                           | E-   | Recommended, not eligible for credits |
| W+         | Eligible for credits and recommended | Z    | Courses outside the curriculum       |
| W          | Eligible for credits                 | Dr   | Suitable for doctorate               |

Key for Hours

| V          | lecture                             | P    | practical/laboratory course         |
| G          | lecture with exercise               | A    | independent project                 |
| U          | exercise                            | D    | diploma thesis                      |
| S          | seminar                             | R    | revision course / private study     |
| K          | colloquium                          |      |                                    |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Module

<table>
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<tr>
<th>Number</th>
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<td>067-0101-00L</td>
<td>Involved Parties</td>
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<td>S. Menz</td>
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<td>Objective</td>
<td>The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.</td>
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<tr>
<td>- Expertise and personal skills</td>
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<tr>
<td>- Organisational forms and SWOT analysis</td>
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<td>- Role, contracting and authority to issue directives</td>
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<tr>
<td>- Responsibility</td>
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<tr>
<td>- Leadership</td>
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<tr>
<td>Lecture notes</td>
<td>Please find the teaching material, the further readings and Information on our server.</td>
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<tr>
<td>Literature</td>
<td><a href="http://www.map.arch.ethz.ch/en">www.map.arch.ethz.ch/en</a></td>
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<td>Competencies</td>
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<td>Concepts and Theories</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Sensitivity to Diversity</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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#### MAS in Building Process Leadership - Key for Type

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<thead>
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<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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#### Key for Hours

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<tr>
<td>V</td>
<td>lecture</td>
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<td>lecture with exercise</td>
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<td>colloquium</td>
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<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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#### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
MAS in History and Theory of Architecture (GTA)

The MAS-programm in “History and Theory of Architecture” is a two-year half-time course and contains 60 CP. The course starts in the autumn semester.

Attendance of classes supplemented by independent research; practical training periods and excursions; lectures/seminars on one to two days per week, in total 600 ca. contact hours, in addition private study ca. 600 hours (for each in-class day one day of work preparation), two individually tutored seminar papers on chosen subjects (200 hours) and credited Master’s thesis (600 hours).

1. Semester

Seminars

<table>
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<th>Number</th>
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<td>056-0001-01L</td>
<td>Architecture and the City I</td>
<td>O</td>
<td>5</td>
<td>4S</td>
<td>A. J. Bideau</td>
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Abstract
Architects have repeatedly addressed the collective in order to counter criticism and to re legitimize their practice. In doing so, they have also turned their attention to episodes in architectural history. The decade 1967-1977 in particular saw important theoretical contributions to the question of the collective emerge. Here the seminar interpolates between practice and the production of theory.

Objective
In order to convey the range of historiographical approaches, different methodological approaches and disciplinary perspectives on the main topic of the semester will be used.

Specific examples will be used to understand the interplay between architectural and urban structures and the messages conveyed or circulating there in their time.

Content
Core questions of seminar:
What makes the theme of the collective central at a particular historical moment? How can this paradigm be contextualized?
What social desiderata are expressed in an architectural and urban form? Under what circumstances does such a representation take place? Who formulates what the collective interest is in each case?
What historiography and theorizing do architects engage in and what insights do they hope to gain for their present?

Literature
Will be posted on the MAS platform.

Prerequisites / notice
Preparatory readings will be indicated in August.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Personal Competencies
Creative Thinking fostered
Critical Thinking fostered
Self-awareness and Self-reflection fostered

Methods

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<td>056-0005-01L</td>
<td>Methods of Academic Writing I</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>A. J. Bideau, S. Hefti</td>
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Abstract
Through hands-on teaching, the methods workshops introduce students to the various approaches to academic writing in the humanities and convey the methodological foundations of architectural history. Lecturers and students discuss and work on research papers and master’s theses as well as the group’s research project.

Objective
Students learn to identify and apply different methods of academic writing in architectural history. They acquire the ability to recognize and independently solve problems related to research and writing.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered
Method-specific Competencies
Analytical Competencies fostered
Project Management fostered
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered
Personal Competencies
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

Study Trips

<table>
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<td>O</td>
<td>2</td>
<td>4P</td>
<td>A. J. Bideau</td>
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Abstract
One-week study trip centered on walking as a method for researching, writing, and communicating architectural and urban history.

Objective
Students will engage in walking as a critical approach to urban and open space; reflect on the relationship of architecture and experience; and read key texts on spatial perception and the history and practice of walking.

Literature
Will be announced on the class platform.

Electives

see “electives” in Architecture BSc and MSc

Essays

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3. Semester

Lectures, Seminars

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<tr>
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Abstract

Architects have repeatedly addressed the collective in order to counter criticism and to re-legitimize their practice. In doing so, they have also turned their attention to episodes in architectural history. The decade 1967-1977 in particular saw important theoretical contributions to the question of the collective emerge. Here the seminar interpolates between practice and the production of theory.

Objective

By analyzing historical texts on architectural theory, students will acquire the skills to understand these sources as voices in their time. In order to convey the range of historiographical approaches, different methodological approaches and disciplinary perspectives on the main topic of the semester will be used.

Specific examples will be used to understand the interplay between architectural and urban structures and the messages conveyed or circulating there in their time.

Content

Core questions of seminar:

What makes the theme of the collective central at a particular historical moment? How can this paradigm be contextualized?

What social desiderata are expressed in an architectural and urban form? Under what circumstances does such a representation take place? Who formulates what the collective interest is in each case?

What historiography and theorizing do architects engage in and what insights do they hope to gain for their present?

Literature

Will be posted on the MAS platform.

Prerequisites / notice

Preparatory readings will be indicated in August.

Competencies

Subject-specific Competencies

Concepts and Theories fostered

Method-specific Competencies

Analytical Competencies fostered

Decision-making fostered

Social Competencies

Communication fostered

Personal Competencies

Adaptability and Flexibility fostered

Creative Thinking fostered

Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered

Self-direction and Self-management fostered

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Workshop

Master's Thesis

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<td>O</td>
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Abstract

This one-semester module is dedicated to identifying the topic for the Master's thesis and developing the research plan. The Master's thesis itself is written in the following spring semester.

Objective

The aim is to develop a relevant hypothesis and research question for the Master's thesis that is based on an analysis of the current state of the field. Additionally, the research plan includes preparing an annotated bibliography, elaborating the methodological approach and a timeline of deliverables.

Content

The topic of the MAS master thesis is chosen by the students and further refined through individual consultation with the docents. At the end of the semester, the students present their research plan to external guest critics. The research plan comprises about 25,000 characters.

Literature

See internal MAS platform
<table>
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<tr>
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### MAS in History and Theory of Architecture (GTA) - Key for Type

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### Key for Hours

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<td>practical/laboratory course</td>
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<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
The course is intended to support the students to develop their individual research proposals and to attain the necessary skills to work independently and with scientific rigour on a research question, to formulating valid hypotheses, and developing a feasible research design. The course is intended to support the students to develop their individual proposals and to possess the necessary skill to work independently and with scientific rigour on a project leading to their final MAS thesis.

Module 2: Innovative Housing: Case Studies and Exercises

A core element of the MAS ETH in Housing is the elaboration of a research proposal that will lead to their MAS theses. Students will critically reflect upon the concept of adequate housing and on the various strategies through which national governments, municipalities, the private sector, and communities in different contexts have, or are addressing the housing question.

Lecture notes
A reader will be distributed at the beginning of the semester containing an overview of all lectures, the involved exercises, and required readings.

Module 3: Housing Research Methods

Lecture notes
A reader will be distributed at the beginning of the semester containing an overview of all lectures, the involved exercises, and required readings.

Module 4: Writing and Communication Skills for Built Environment Professionals

Lecture notes
A reader will be distributed at the beginning of the semester containing an overview of all lectures, the involved exercises, and required readings.

Elective Courses

You need to attend one Seminarweek (2 CTs).

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### MAS in Housing - Key for Type

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**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
1. Semester

Core Courses

General Management and Human Resource Management

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Abstract

This course is an introduction to general management. This course follows a systemic view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations.

Objective

By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations to achieve their goals and to coordinate operations in order to meet evolving customers’ and societal needs. The students will achieve these goals by being able to:

- Analyze organizations as open systems, and describe their critical elements,
- Apply conceptual tools and methods that help to analyze or approach the critical elements,
- Compare different notions of organizational performance, and explain why they matter,
- Discuss the relationships that connect the critical elements of an organization on the basis of real cases,
- Explain how change, internally or externally initiated, impact such relationships

Content

This course is an introduction to general management. This course follows a ‘systemic’ view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations: Input (i.e., from external environment), strategy, people, work, formal and informal structure of the organization, and its outputs. In this course we will introduce these critical elements and learn how managers can analyze and approach these elements by means of different conceptual tools and methods in order to achieve performance. We will furthermore discuss the relationships that connect the critical elements together by means of real-life cases, whereby the focus will be on the critical reflection of particular cases of fits and misfits between those elements and on the application of a selection of tools and methods.

Lecture notes

The content of the course will rely on different readings, cases and selected chapters of following book:


Selected readings from the book and additional learning materials will be available on the course Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=20842

Literature

The content of the course will rely on different readings and on selected chapters of following book:


Selected readings from the book and additional learning materials will be available on the course Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=20842

Prerequisites / notice

Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students on moodle. This preparation is required to participate in the lectures.

The final exam is requested for all types of students (BSc, MSc, MA, PhD, and Exchange students). It is not possible to retake the exam within the same term or academic year. We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

Method-specific Competencies
- Cooperation and Teamwork fostered
- Leadership and Responsibility fostered
- Adaptable and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Adaptability and Flexibility fostered
- Adaptability and Flexibility fostered
- Adaptability and Flexibility fostered

363-0301-00L Work Design and Organizational Change

Abstract

Good work design is crucial for individual and company effectiveness and a core element to be considered in organizational change. Meaning of work, organization-technology interaction, and uncertainty management are discussed with respect to work design and sustainable organizational change. As course project, students learn and apply a method for analyzing and designing work in business settings.

Objective

- Know effects of work design on competence, motivation, and well-being
- Understand links between design of individual jobs and work processes
- Know basic processes involved in systematic organizational change
- Understand the interaction between technology and its impact on organizational change
- Understand relevance of work design for company performance and strategy
- Know and apply methods for analyzing and designing work

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The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterium
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

A list of required readings will be provided at the beginning of the course.

The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.

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Strategy, Markets and Technology

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<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>F. von Wangenheim, P. Bachmann</td>
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Abstract
This course provides an overview on essential perspectives of marketing and how marketing adds value to a business. It will teach concepts, frameworks and methods for marketing decision making. The course will also look at issues related to marketing implementation. Thereby, a particular focus will be on how data and data analytics can help to support marketers in their decision making.

Objective
After taking the class, students will be able to

1) Understand how marketing adds value to a business.
2) Provide an overview of key concepts in marketing that are applicable to any business.
3) Understand how consumers behave and how this impacts marketing
4) Learn how analytics and quantitative methods can help to improve decision making in marketing.
5) Get to know the elements that shape a firm’s marketing strategy (segmentation, targeting, positioning) and marketing tactics (product, price, promotion, place).

Content
The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their customers. It will teach concepts, frameworks and methods for marketing decision making. Specifically, the course is aims to provide students with a) an overview on the role of marketing within a business, b) details on strategic marketing management decisions and tools, c) a profound knowledge on the individual elements of the marketing mix (product, price, promotion, place), d) an awareness of specific contexts of marketing, and e) first-hand experience on data-driven techniques to support marketers’ decision making.

Thus, this course will introduce key analytical tools to help solving respective managerial tasks. This is a lecture with integrated exercises. Access to a laptop is required for the exercises. The class might be thought in an in-person, remote or in a hybrid format. Students might also be taught via pre-recorded videos and assigned material for self-study.

Literature

The course might comprise mandatory and supplemental reading material. Other literature may be assigned in class.
This course provides an overview of Digital Transformation within organizations, the opportunities that come with it, but also the issues managers face transforming their organizations into the digital age. Increasingly, information technology (IT) is not only being used as a tool to improve processes but to also create and capture new customer value and to gain and maintain competitive advantage.

Objective

This course introduces to the students the relevant subjects that form the digital transformation agenda of organizations' top-level management. After completing the 4 core learning blocks below, students will be able understand, analyze and critically question organization’s digital transformation processes while also learning the frameworks and tools used by organizations to digitally transform.

Content

Digital Transformation has become a top management theme across all industries. It is part of the strategic agenda of management and supervisory boards with dedicated roles to drive forward its design and implementation.

The course introduces many of the relevant subjects that together form the digital transformation agenda of organizations’ top-level management. It establishes the main themes, tools, and theoretical concepts. The course consists of 4 learning blocks, each with a focus on an area of Digital Transformation, and will feature guest lecturers from industry. The course is structured as follows:

Block 1: Strategy
- Digital Business Model Patterns
- Platform Companies
- Subscription Models
- Lessons from Theory Toolbox

Block 2: Organizational
- Towards an Agile Organization

Block 3: Technology
- “Future-proof” Infrastructure

Block 4: Industry
- Digital Transformation in the Health Care Industry
- Digital Transformation in the Automotive Industry

Throughout the course, students will learn from and discuss with guest lecturers their experiences of digital transformation.
Objective
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:
1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

Content
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM, Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Literature
Suggested literature is provided in the syllabus.

Competencies
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<th>Social Competencies</th>
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Quantitative and Qualitative Methods for Solving Complex Problems

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<tr>
<td>363-0541-00L</td>
<td>Economic Dynamics and Complexity</td>
<td>W+</td>
<td>3</td>
<td>3G</td>
<td>F. Schweitzer, L. Verginer</td>
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Abstract
What causes economic business cycles? How are limited resources, competition, and cooperation reflected in growth dynamics? To answer such questions, we combine macroeconomic models and methods of nonlinear dynamics. We study the role of bifurcations and control parameters for dynamic stability. Feedback cycles and coupled dynamics are reasons for limited predictability, instability and chaos.

Objective
The successful participant of the course is able to:
- understand the importance of different modeling approaches
- formalize and solve one- and two-dimensional nonlinear models
- identify critical conditions for stability and dynamic transitions
- analyze macroeconomic models of business cycles, supply and demand
- apply formal concepts to model economic growth and competition
Adaptability and Flexibility

Analytical Competencies

Lecturers fostered assessed

Communication assessed

Subject-specific Competencies

Creative Thinking assessed

Principles of Macroeconomics

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

Weekly self-study tasks are used to apply the concepts introduced in the lectures.

We practice how to solve nonlinear models formally and numerically and how to interpret the results.


This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Weekly self-study tasks are used to apply the concepts introduced in the lectures.

We practice how to solve nonlinear models formally and numerically and how to interpret the results.


This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Micro and Macroeconomics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>J.-E. Sturm</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?</td>
<td></td>
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<tr>
<td>Objective</td>
<td>This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.</td>
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</tr>
<tr>
<td>Content</td>
<td>This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>The course Moodle page contains announcements, course information and lecture slides.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>The set-up of the course will closely follow the book of N. Gregory Mankiw and Mark P. Taylor (2023), Economics, Cengage Learning, 6th Edition. This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).</td>
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363-0565-00L

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<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0565-00L</td>
<td>Principles of Microeconomics</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Filippini</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.</td>
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The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a fair distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature


For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories assessed</td>
<td>Communication fostered</td>
<td>Adaptability and Flexibility fostered</td>
</tr>
<tr>
<td></td>
<td>Techniques and Technologies fostered</td>
<td>Customer Orientation fostered</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies assessed</td>
<td>Leadership and Responsibility fostered</td>
<td>Critical Thinking fostered</td>
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<td></td>
<td>Decision-making assessed</td>
<td>Self-presentation and Social Influence assessed</td>
<td>Integrity and Work Ethics fostered</td>
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<td></td>
<td>Media and Digital Technologies fostered</td>
<td>Sensitivity to Diversity fostered</td>
<td>Self-awareness and Self-reflection assessed</td>
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<td></td>
<td>Problem-solving assessed</td>
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<td>Self-direction and Self-management fostered</td>
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<th>Number</th>
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<tbody>
<tr>
<td>363-0711-00L</td>
<td>Accounting for Managers</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>H. Chen, to be announced</td>
</tr>
</tbody>
</table>

Abstract
The course Accounting for Managers offers an introduction to financial and managerial accounting, especially for students who aspire for a career in business and management with a science or engineering background.

Objective
After attending the class, you should be able to:
- understand the accounting system, the reporting process, and be able to prepare financial statements
- feel comfortable reading and using the information presented in companies' annual reports
- understand cost concepts and conduct cost analyses
- become familiar with several classic decisions using managerial accounting information
- comment on the current events related to these topics

Content
Accounting plays a critical role in the effective functioning of the financial market as well as the long-term success of a company. This course intends to provide an introduction to accounting for those who wish to pursue a career in business, and need the skills and knowledge to understand, analyze, and interpret accounting information to make informed decisions. The course is divided into two parts. In the first part, we focus on financial reporting and start with the basics accounting concepts and the accounting cycle, to learn how the financial system is set up in a company and how financial statements are prepared. We then delve deeper into each major account, and discuss how revenues and expenses are recognized, and how assets, liabilities, and equities are reported. In the second part, we focus on managerial accounting for internal managerial/operational decisions including fundamental topics such as cost behavior, cost estimation, CVP analyses, and relevant costing. We then cover budgeting and standard costing, which are important parts of accounting system in companies.

Prerequisites / notice
This course is a prerequisite for the course Financial Management.

<table>
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<tr>
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<th>Concepts and Theories assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies assessed</td>
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</table>
Corporate Governance explores the intrinsic conflicts of interest in modern corporations, their impact on economic outputs, and the history of related scandals. The course discusses governance improvements, capital market developments, and ESG-focused reforms. It discusses mechanisms to align the interests of managers, shareholders, and other key stakeholders.

Objective
After taking this course, students will be able to:
- Analyze the complex spectrum of incentives facing different stakeholders in modern corporations, utilizing real-world mini-case studies to understand how these incentives can sometimes be dysfunctional.
- Gain a robust theoretical and practical understanding of how corporate democracies function and the dynamics of capital markets, equipping them with the knowledge to navigate and influence these environments effectively.
- Assess and critique the current incentive structures within corporations, drawing on a variety of academic and professional sources to understand the challenges and solutions proposed in the field of corporate governance.
- Conduct their own empirical research on corporate governance topics, applying methodologies and insights from both established and recent scholarly papers, thus developing skills necessary for academic and applied research in this area.
- Integrate concepts of sustainability and ESG (Environmental, Social, and Governance) factors into their understanding of corporate governance, recognizing the growing importance of these elements in shaping modern business practices and regulations.

This comprehensive skill set will enable students to critically engage with and contribute to discussions and developments within the field of corporate governance, preparing them for roles that require nuanced understanding of corporate structures and stakeholder interactions, including corporate acquisitions, security design, and management compensation.

Content
Target Audience
This course is designed for advanced master's students who have professional experience and a strong interest in finance, top management, and critical aspects of modern corporations.

Prerequisites
Students should have a solid understanding of foundational concepts in corporate finance and financial economics, including:
- Discounting and compounding
- Time value of money
- Net present value rule for investment projects
- Key characteristics of stocks and bonds
- Foundations of modern portfolio theory
- Capital Asset Pricing Model (CAPM)
- Black-Scholes option pricing formula
- Capital structure theories

Course Content
The course explores the conflicts of interest among various stakeholders in modern corporations, such as shareholders, management, bondholders, suppliers, customers, employees, governments, local communities, the environment, and society at large. Through case studies and empirical analysis, the course examines the detrimental effects of poor governance structures and their costs to both shareholders and other stakeholders. It discusses:
- Theoretical and empirical aspects of management compensation
- The roles and the characteristics of boards of directors, including CEO retention decisions
- The impact of different investor types and ownership structures on the well-functioning of corporate democracies and the market for corporate control
- The importance of voting rights in contrast to traditional views of stock as merely cash-flow rights

Course Structure (subject to changes)
1. Introduction
2. Consequences of Poor Governance
3. Empirical Methods in Corporate Governance Research
4. Monetary Incentives
5. The Board of Directors
6. The CEO Retention Decision
7. Ownership & Control
8. Shareholder Voting
9. The Hostile Acquisition Threat
10. Firms vs. External Stakeholders

References
No textbook is required for this course. For further reading, students may refer to:

Multimedia supplements, including screencasts and short video clips, will support key topics.

Course Deliverables
- Active participation in class discussions
- Group presentations
- A 60-minute written exam, which will serve as the basis for grading.

3. Semester
Core Courses
Strategy, Markets and Technology

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0387-00L</td>
<td>Corporate Sustainability</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Hoffmann, C. Bening-Bach, B. Girod, L. Miehé</td>
</tr>
</tbody>
</table>

Abstract
The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. The module combines asynchronous videos, live sessions, with a group work phase between weeks 5-10 of semester during which students deep-dive into one of 10 sustainability challenges.

Objective
Students
- assess the limits and the potential of corporate sustainability for sustainable development
- develop competencies that are useful in the context of corporate sustainability and beyond (analytical competency, critical thinking, problem solving)
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams
The Strategic Management course aims to impart relevant competencies in strategic management, both for professional and academic development. This course offers an introduction to the fundamentals of strategy and the most widely used concepts and methods in strategic management. The course is delivered through a combination of lectures on concepts and methods, as well as case studies where students work on solving strategic issues of the case companies. The course participants will also have the opportunity to engage with firm executives, gaining insights into the real-time strategic challenges that organizations encounter, thereby acquiring practical experience.

To succeed in the course, course participants are expected to read and understand the required readings, which consist of publications covering the most important research in management and strategy.

To emphasize the relevance of Strategic Management in real-world situations, senior executives of Swiss companies will hold guest lectures to provide their insights on strategy in practice and current topics in the field.

The Strategic Management course delivers a comprehensive learning experience by integrating lectures on fundamental theories and concepts with practical case studies. This approach allows course participants to develop a deep understanding of essential and contemporary issues in the field, while providing opportunities for the practical application of these theoretical insights to strategic challenges faced by businesses.

The course focuses on competitive strategy, which involves analyzing and establishing a firm's position within an industry to ensure its performance. This is achieved through exploring topics such as industry structure, industry evolution, and the analysis of a firm's resources and knowledge, as well as innovation.

For further questions and if you are unable to sign up through myStudies, please contact the course assistant: http://www.smi.ethz.ch/education/strategic-management.html

For participants of the MAS-MTEC program we offer a complementary course Practicing Strategy in which students will apply the concepts of Strategic Management to their real-life contexts and organizations. Please register simultaneously for both courses if you want to take part in this course.

For more information please see: http://www.smi.ethz.ch/education/practicing-strategy.html

For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Selected literature:
- Literature recommendations will be distributed via Moodle, and are available from the start of the course.

For more information please see: http://www.smi.ethz.ch/education/practicing-strategy.html

For participants of the MAS-MTEC program we offer a complementary course Practicing Strategy in which students will apply the concepts of Strategic Management to their real-life contexts and organizations. Please register simultaneously for both courses if you want to take part in this course.

For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Prerequisites / notice

363-0392-00L Corporate Sustainability is the flagship course of the Group for Sustainability and Technology at D- MTEC. In this course, students learn about key concepts in corporate sustainability and develop skills to implement them in the real world. The course prepares students for making well-informed sustainability decisions in their future careers.

The course uses constructive alignment to bring the various innovative teaching and learning elements (e.g., case-based experiential learning, reflective thinking and blended learning with videos and quizzes) into a coherent transformational journey. Students can now flexibly, efficiently, and effectively acquire the conceptual foundations that are essential for a substantial understanding of corporate sustainability.

For part of the course, students work in groups to complete a set of graded assignments designed to guide them into a deep dive on a selected corporate sustainability challenge. Please note that full participation in this part is essential, so make sure you are available. Furthermore, these group assignments count towards the overall grade for the course.

For more information please see: http://www.smi.ethz.ch/education/strategic-management.html
Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage. After completing this course:

- Students will familiarize students with modern supply chain management theory and practice to develop and manage supply chains.

Starting with the corporate strategy, firms align their supply chain strategy. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain’s role within a firm and the implications of supply chain strategies for firm performance are the foundations of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management and transportation. At the same time, supply chain management is inevitably cross-functional. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge.

The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>Techniques and Technologies</td>
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</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>-</td>
<td>Decision-making</td>
<td>assessed</td>
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<td>-</td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td>-</td>
<td>Problem-solving</td>
<td>assessed</td>
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</tr>
<tr>
<td>Social Competencies</td>
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<tr>
<td>Personal Competencies</td>
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<tr>
<td>-</td>
<td>Creative Thinking</td>
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<td>-</td>
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<td>-</td>
<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>-</td>
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### Information and Operations Management

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0453-00L</td>
<td>Strategic Supply Chain Management</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>S. Wagner</td>
</tr>
</tbody>
</table>

**Abstract**

The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms competitive strategies and marketing priorities.

**Objective**

After completing this course:

1. Students can explain the importance of supply chain management for a firm’s strategy and success
2. Students are able to apply the tools and methods used to optimize a supply chain structure
3. Students can differentiate supply chain network designs and their applicability in specific company and sector settings
4. Students can describe and evaluate fundamental logistics and supply chain concepts
5. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy
6. Students are familiar with current developments and trends in supply chain practices

**Content**

Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage in globalized (supply) markets with numerous partners and competitors. While taking into account future opportunities and risks, effective supply chains ought to be aligned with and support the achievement of the firm’s corporate, business and product strategies. This course will familiarize students with modern supply chain management theory and practice to develop and manage supply chains.

Starting with the corporate strategy, firms align their supply chain strategy. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain’s role within a firm and the implications of supply chain strategies for firm performance are the foundations of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management and transportation. At the same time, supply chain management is inevitably cross-functional. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge.

The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.

**Lecture notes**

The course material will be made available for download on Moodle:

https://moodle-app2.let.ethz.ch/course/view.php?id=20606

All organizational matters will be handled by the teaching assistant Yan Zou (yanzou@ethz.ch). Please use the SSCM Class Forum on Moodle as a first point of contact.

**Literature**

The following textbook is recommended:


The following textbook is supplementary:


**Prerequisites / notice**

Students should install MS Excel and the Excel Solver before class, as it is used for within-class exercises. Students without the program and add-in installed may nevertheless participate within groups during the exercises.
The lecture treats the main challenges of business transformation and the alignment of corporate development and IT activities. It presents a holistic approach to business transformation projects by introducing an integrated model dealing with three main design areas “strategy”, “processes” and “information systems” and applying this model to various case studies.

The goal of the lecture is to understand the main challenges of corporate transformation and to demonstrate the application of a holistic project procedure model for corporate transformation projects with special emphasis on the alignment of business and IT.

The student should understand and be able to explain the main reasons for corporate transformation, the relevant management processes to manage corporate transformation, the interdependencies between strategy, processes and information systems, especially how this three levels interrelate, the critical success factors for the successful accomplishment of large scale corporate transformation projects, the main instruments of project, quality and change management and the different types of resulting IT projects.

Data has become an important resource in today’s business environment, which can be used to make better management decisions. In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evident-based decision-making. The class includes assignments related to the lecture content.

The globalization of the world leads to an increasingly faster pace in business transformation. Enterprises have to adapt faster and even faster to the environmental changes in a global economy to remain competitive and to make sure they stay in business. In todays information age this does not only mean to adapt business strategy and business processes but also to adapt information systems to the new circumstances. The fast adaptation trough large scale corporate transformation projects that change strategy, business processes and information systems is critical to ensure competitiveness for tomorrow. The introduction of new business processes and information systems typically takes years in very complex large scale projects. Many projects fail because of insufficient alignment between decision makers in business and IT. Unclear understanding of the overall project scope, undefined roles and responsibilities, unclear project processes, quality problems and resistance to change are some typical problems found in such projects. The lecture is subdivided into following modules:

Corporate development introduction and motivation,
Parallelization of corporate development and complexity reduction,
Planning process and project portfolio management in corporate development,
Management of large scale projects integration of strategy, processes and information systems,
Quality management in large scale projects,
Project management in large scale projects,
Change management within projects. The lecture is accompanied by four case studies that are used to exemplify the contents of the lecture by applying the concepts to real situations in corporate life.

The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis are fostered. However, evidence-based decision-making comes along with challenges and requires a basic understand of statistical approaches.

In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evident-based decision-making. The class includes assignments related to the lecture content.

The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understand of statistical approaches. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature. Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics.

The lecture will be taught in presence. There will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.

The student should understand and be able to explain the main reasons for corporate transformation, the relevant management processes to manage corporate transformation, the interdependencies between strategy, processes and information systems, especially how this three levels interrelate, the critical success factors for the successful accomplishment of large scale corporate transformation projects, the main instruments of project, quality and change management and the different types of resulting IT projects.

The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics.

The lecture will be taught in presence. There will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.
The economic environment of today's companies is characterized by high cost pressure, declining margins, intensified international competition, rising customer requirements and increasingly strict regulations. Strategic and operational decisions at all management levels are becoming more and more complex due to the increasing amount of data, interrelationships, conditions and target criteria to be considered. Often it is no longer possible to solve operational tasks with experience and common sense alone and to adequately estimate the consequences of decisions without software support.

Quantitative models and methods of operations research and operations management offer decision support for complex problems. Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analysed and optimized using suitable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:
- Introduction to system modelling and operations research
- Linear models and programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

A printed script will be made available.

Any standard textbook in Operations Research is a useful complement to the course.

Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.

### Micro and Macroeconomics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0537-00L</td>
<td>Resource and Environmental Economics</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>A. Minabutdinov</td>
</tr>
</tbody>
</table>

**Objective**
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

**Content**
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewables resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

**Literature**

**Competencies**
- Subject-specific Competencies: Concepts and Theories assessed
- Techniques and Technologies assessed
- Analytical Competencies assessed

### Financial Management

#### Skill-Based Training, 1. and 3. Semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>365-1099-00L</td>
<td>Design Thinking: A Human-Centred Approach to Problem Solving</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>D. Salehabadi</td>
</tr>
</tbody>
</table>

**Abstract**
In this course, students get to know Design Thinking, which is an innovation method that can be applied to a broad range of problems from product development to social innovation. The students will engage in collaborative team exercise to learn about and directly apply the five typical design thinking steps – empathize, define, ideate, prototype and test – by solving a real-world challenge.

**Objective**
During the course, students will...
- get to know the design thinking process working on a specific real-world challenge
- learn when to apply design thinking methodology
- learn how to empathize with users, how to formulate a clear problem statement, develop ideas, prototype as well as test them with potential users.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1669 of 2667
Content
During the course, students will...
...get to know the design thinking process as:
- - a methodology to develop ideas and concepts – typically in the early phase of the innovation process (the fuzzy-front end)
- - a methodology used for product, service and business model innovation
- - a methodology used for organizational development: process improvements, redesign of organizational structures, etc.
- - learn how to apply the design thinking methodology or parts of it
- - learn how to empathize with users: simple interview techniques, observation, etc.
- - learn how to formulate a clear problem statement
- - learn to develop ideas: potentially alternative brainstorming techniques
- - learn how to prototype ideas with simple means
- - learn how to test them with potential users: simple test structures

What the students should learn from the course:
- Students will be able to assess whether Design Thinking is useful methodology to solve challenges they face in their daily business activities
- Students will be able to use elements (i.e. a novel brainstorming technique, a novel feedback method, etc.) in their daily business activities

What the students will NOT learn:
- This 3-day training is by not extensive enough to provide a full-scale design thinking training that enables students to design, organize and run their own design thinking workshops and projects. For this, further courses, trainings and self-guided learning is necessary.
- References to institutes, books and other material will be provided.

Lecture notes
There is no script available.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Credits</th>
<th>Study Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>365-1019-00L</td>
<td>Human Resource Management: Skills in Practice</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
</tr>
</tbody>
</table>

Abstract
Based on several core Human Resource Management processes, this seminar teaches practical skills in HRM and leadership in teams.

Objective
Participants are able to cope with potentially difficult HRM-related situations they may encounter as line managers and team leaders.

Content
Based on four Human Resource Management core processes (recruiting, performance management, compensation, training and development), this seminar focuses on practical skills in HRM and leadership in teams from a managerial point of view. Using a variety of interactive methods and discussions of real-life situations, it provides a highly practice-oriented approach to dealing with potential HRM- and team-related conflicts at work.

Prerequisites
Prior participation in the lecture "Human Resource Management: Leading Teams" (363-0302-00) in spring semester is recommended.

Literature
Will be announced and published ahead of each session.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Credits</th>
<th>Study Period</th>
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</thead>
<tbody>
<tr>
<td>365-1053-00L</td>
<td>Innovation, Creativity and Personality Traits</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
</tr>
</tbody>
</table>

Abstract
In this course we use the latest research on how individuals can improve at solving problems creatively to foster their careers, and the performance of their organization.

Objective
1. Participants will generate a richer notion of innovation and creativity by reflecting on the role of individuals on the innovation processes, the cognitive abilities and personality traits that are involved in this process
   o Through a personal assessment, participants will learn how the discussed cognitive abilities and traits are observable and measurable
   o Through a personal assessment, participants will learn about their own cognitive abilities and personality traits related to innovation and creativity and in comparison with other groups with similar backgrounds.

2. Participants will gain awareness of the use of their own creativity and problem-solving skills and will learn the reasons why these type of processes can foster creativity and innovation in their daily life and their jobs
   o Through discussions with field experts and the knowledge from their self-assessments, participants will gain insight on the fit or misfit of career paths and cognitive abilities and personality traits
   o Through the workshop debrief session, participants will learn the reasons why these type of processes can foster creativity and innovation.

3. Participants will create one and receive one concrete and actionable plan for helping someone overcome one weakness in their own work environment. Participants will also learn from the plans created by their peers.
In this course, we introduce the process of innovation and the role that individual creativity has on it. Individual creativity is composed of many abilities. This course gives the participant tools and methods to make many of these hidden, yet critical, abilities observable and measurable. On this basis, the participant can develop a concrete action plan to improve on them.

The course has three parts. In the first, we introduce the process of innovation and creativity. We go deep in this process and explain the role that individual cognitive abilities and personality traits have on innovation and creativity. We make these ideas concrete by providing each participant with the experience to take a self-assessment. The self-assessment gives the participant concrete feedback on their cognitive abilities and personality traits, also in comparison with their peers. We call this “self” assessment as all feedback is provided only to the participant for them to make their own conclusions.

In the second part of the course, industry experts come and give guidance to participants on how to use their cognitive abilities and personality traits at the workplace. They explain how these abilities are critical to career development, and career transitions. Everyone has strengths and weaknesses and the experts explain how matching one’s profile to one’s career can lead to efficient and fulfilling outcomes.

The third part of the course involves a design-thinking workshop where participants work in pairs. Each participant is tasked with finding an actionable plan for helping another participant with improving the ability of their choice. In this part, we reconnect to the first part of the course: participants can choose a specific ability learned on their self-assessment. After the workshop is finished every participant has a prototype that should help them in the process of personal development after the course is over.

In this way, this course is meant as a starting point for personal development. It introduces the process of innovation from an individual point of view and presents the core abilities needed in the process. It provides guidance for matching careers and abilities. Finally, the course gives a concrete action plan, in the form of a personalized prototype solution to continue the personal development after the course is finished.

Prerequisites / notice
Please notice that participation in the entire two days of the course is a requirement. Due to the short duration of the course and its highly interactive nature, there are no exceptions.

365-1149-00L Introduction to Personal Branding and Storytelling

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Problem-solving</td>
<td>fostered</td>
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<tr>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Creative Thinking</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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</table>

Minimum number of participants: 15 students

Abstract
We all have a “personal brand” - whenever you are interacting others, you are projecting an image of yourself. Are you ready to take charge of your own brand story and proactively guide your image? Would you like to learn how to effectively tell your story in a memorable way? This course will teach you skills you can rely on throughout your career to help you achieve your goals.

Objective
This highly interactive course will help you to understand and then define your own brand story. By carefully looking at your own values, attributes and strengths from an internal and external perspective, you will first define a genuine and meaningful personal brand for yourself and then learn the storytelling skills you will need to authentically connect with and influence your audience. In addition, you will look at the various channels of communication you can use to proactively build your personal brand, with particular attention on LinkedIn.

Specific take-aways from this course:
- Your current personal brand
- Your desired personal “brand house”
- Storytelling frameworks
- Building of your personal story and practice giving it
- Review of online & offline communication channels with an action plan to activate
- Revision of your LinkedIn profile to reflect your personal brand
- Your Personal Journal to keep and reflect on throughout your career as well as the toolkit you need to refresh your brand house as needed

Content
The Personal Branding and Storytelling course will be divided into the following sessions:
Pre-Work: you will be expected to distribute a survey to 5-6 members of your trusted network (e.g. friends, family and work colleagues). The surveys are private and only you will see the information. The survey will be the basis of defining your current personal brand. Additional pre-work will be reading through some articles and completing the first section of your Personal Journal.
Brand Basics: gain a common understanding of what a brand really is and why it is important. We will explore the difference between a corporate brand and a personal brand.
Brand Building: using the pre-work material, we will look at your current personal brand vs. your desired brand. We will take an in-depth look at all parts of a brand house and help you define your own Unique Selling Points (USPs). We will have exercises and break into small teams as needed.
Storytelling Basics: gain a common understanding of the importance of storytelling and different frameworks to approach it.
Storytelling Practice: you will spend time developing your personal story. We will have exercises and break into small teams as needed.
You will be given the opportunity to tell your story and obtain feedback.
Communication Channels: we will review the various online and offline communications channels open to you to build your brand with a strong focus on LinkedIn. You will develop a personal action plan based on the channels most relevant to your industry and profession.
Post-Work: all students are asked to load a video of themselves where they showcase their personal brand and then do peer-to-peer reviews.

Attendance at both days of the course, active participation in the exercises and finishing the post-class assignment is mandatory for successful completion of the course. Students will be expected to fully complete the pre-work required, including gathering the Trusted Network Survey data and filling in the first part of the Personal Journal. Literature and readings will be announced beforehand.
**Negotiation Skills**  
*Exclusively for MAS MTEC students (3rd semester).*

**Abstract**  
Participants are introduced to practical frameworks for negotiations and apply them in negotiation simulations, discussions, and exercises.

**Objective**  
In this course, participants are introduced to the practical dimensions of how individuals and organizations represent their interests in negotiations.

Participants will learn basic frameworks and theories for:
- negotiation context analysis
- preparing to negotiate
- best-practices for effectively negotiating

and apply them to practical contexts through discussions, group exercises, and simulations.

**Content**  
This two-day skills course gives students a basic introduction to how individuals and organizations represent their interests and create value in negotiations, which are often defined as exchanges between parties designed to reconcile their differences and produce a settlement. The course comprises a mixture of lectures, discussions, group work, and simulations. Students do not need any experience or knowledge of negotiations, though those that do are invited to share their experience in discussions.

The first day focuses on:
- Planning and preparation for negotiations
- Analyzing and understanding different types of negotiation contexts
- Common frameworks for negotiations
- 2-party negotiation simulation

The second day focuses on:
- Social dimensions (power, influence, persuasion, behavior cues, culture, and gender) of negotiations
- Ethics and ethical dilemmas in negotiations
- 5-party negotiation simulation

The course is structured to give an introductory overview of the topics. Recommended readings for further studies will be provided on moodle. Students are required to read the instructions for the negotiation simulation before arriving in class. Attendance and participation are required on both course days.

**Literature**

Pre-session reading is composed of:
- instructions/mandate for a negotiation simulations (before each session)

All required and recommended readings will be available on moodle.

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**Personal Leadership Skills**  
*Exclusively for MAS MTEC students in the 3rd semester of class 2023-2025.*

Please register by 01.08.2024 at the latest via myStudies.

**Abstract**  
With the aim of preparing the students to take on managerial responsibility, this 2x3 days-seminar teaches basic and practical management skills.

**Objective**  
To convey management behaviour based on practical examples, own experiences, and team discussions complemented by short theory sessions (subsidized from the donation for promotion and training in enterprise sciences at the ETHZ).

**Content**  
When talking of leadership, one in most cases refers to the interaction between superior and associate. However, leadership in modern times also involves the interaction with peers, with one’s own superior as well as with other stakeholders. Thus, not leadership but personal leadership skills are needed which also comprise communication, self-management, and personality aspects.

In the light of this, this seminar offers you the opportunity to acquire competencies in all of the just mentioned subjects and to reflect on your current behaviour as (future) leader. The more familiar we are with ourselves, the more we become aware of our needs, the freer we are to express ourselves and to interact with others.

The seminar will be a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays to give you the opportunity not only to get to know the relevant theories and models, but also to apply and test them. This shall enable you to return to your daily work life and be ready for the challenges of being a (future) leader.

Be familiar with and feel able to able current concepts and theories related to leadership skills based on practical examples, own experiences, and team discussions complemented by short theory sessions.

**Content:**
1. Fundamentals of Communication
2. Communication in Business Life
3. Self-Management
4. Personality and Understanding Human Nature
5. Fundamentals of Leadership
6. Leadership Tools
Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving

Method-specific Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Social Competencies

- Decision-making
- Problem-solving
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

365-1189-00L

Personal Leadership (1/4): Sharpen Your Communication Skills

W

Exclusively for MAS MTEC students in the 1st semester of class 2024-2026.

Abstract

Leadership starts with communication: Conveying one’s message and the related needs to the other person or listening to the other person and checking whether one’s understanding is correct can be challenging because it is not only verbal, but also para- and nonverbal communication which are key. With this seminar you sharpen your skill set and learn how to make your communication more effective.

Objective

By attending this first of in total four seminars covering leadership skills, you will:

- Sharpen your general communication skills: Become able how to successfully manage all relevant verbal but also para- and nonverbal components of communication to create and maintain successful communicative interactions which are respectful, goal-oriented and at eye-level.
- Boost your communication skills as a leader irrespective whether you are a project leader, subject matter expert, scrum/agile master, team lead in a self-organised team or hierarchical leader: Have the communicative skills to manage key situations in a business context such as presentations, meetings, recruiting interviews but also a potential termination dialogue.

Content

This seminar targets people that lead or wish to lead – in the role of project leader, subject matter expert, scrum/agile master, team lead in a self-organised team or hierarchical leader – and want to improve their communicative skills as they are key to build and maintain sustainable (work) relationships of any kind. In order to not only learn about tools and strategies to make communication more effective, but also to directly try them out and test them, the seminar builds on a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays. This shall enable you to return to your daily (work) life as a better communicator but also to be ready for the challenges of being a current or future leader.

The first seminar day focuses on sharpening your general communication skills. You will learn among others what communication really is and which components are needed to make communication successful. You become aware of how to phrase a message to make it as easily understandable as possible, if necessary by also taking into account cultural differences. Furthermore, you will work on your inner clarity, will improve your listening skills and will become able to read the para- and nonverbal cues of the other person in order to adapt your own communication to what has not yet been fully said.

The second seminar day focuses on boosting your communication skills as a leader: You will learn how to structure the content of a presentation or text in a listener- or reader-friendly way to increase your argumentative impact while also working on your voice and nonverbal expression to become even more persuasive. The rest of the day will focus on key situations in a business environment, i.e. how to make meetings more interactive and thus successful, how to manage a recruiting process to retain the most promising candidate for the open position but also how to terminate an employment relationship in a respectful way so that you prepare the toughest of all possible communicative situations in a safe environment.

Electives, 1. and 3. Semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>365-1145-00L</td>
<td>Managers' Guide to Investing</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>P. Romann</td>
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</tbody>
</table>

Abstract

This is a practical guide to investing for decision makers. Successful investing requires an understanding of assets, markets, and strategies to achieve your financial goals. Whether you delegate this task or get involved personally, you need to understand how professional investing works.

Objective

The goal is to enable you to define your own personal investment strategy.

- Understand your pension fund as one of your largest investments
- Learn from pension fund investment methodology
- Understand main asset building blocks: stocks, bonds, and alternatives
- Understand how markets work are influenced by central banks
- Appreciate importance of leverage, arbitrage, and the role of derivatives
- Design your first investment strategy
1. How your Pension Fund works?
- Contributions vs. Investments: how assets are built up over decades
- Assets vs. Liabilities, Investments vs. pension promises
- Choice of risk level: asset-liability derived investment dictates risk level
- Importance of conversion rate: how your pension salary fluctuates
- Your potential flexibility: discover personalization your pension fund offers

Case Study: Understand key information of your pension fund

2. How your Pension Fund invests?
- Asset classes: the pillars of pension fund investing
- Diversification and risk: the main line of defense for pension funds
- Optimal asset-allocation: how pension fund decides on asset mix
- Passive vs. active: why active fails and pension funds passivize investments
- ESG factor considerations

Case Study: Portfolio optimization techniques

3. How Markets work?
- Monetary policy: central banks decide on interest rates impacting markets
- Fiscal policy: governments borrowing to finance projects, risk of debt
- Inflation: how it is controlled, and when it is not
- Developed vs. emerging markets: higher growth at higher risk
- Market cycles: the dynamics of markets and economy

Case Study: Covid crash 2020, Post Covid bubble 2021, Inflation crash 2022

4. How Asset Classes work?
- Bond markets and valuation: why bond prices fall when interest rates rise
- Stock markets and valuation: why stock prices fluctuate
- Derivative instruments: key concepts and how to use them without the math
- Alternatives: Private Equity, Hedge Funds, Insurance Linked

Case Study: Stock valuation; Bond risk measure: “duration”

5. How to design my Personal Investment Strategy?
- Start with the pension fund methodology: what can I learn?
- Investment horizon: long-term vs. short-term
- Risk capacity and appetite: Biting off more than one can chew
- ESG other criteria
- My personal “edge”

Case Study: Design/explain/defend your personal strategy

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Analytical Competencies
In today’s VUCA world that is Volatile, Uncertain, Complex and Ambiguous, how will you lead disruptive change due to Innovation and fostered

Subject-specific Competencies
Literature and readings will be announced beforehand.

After taking this course, students will be able to:
- have a basic, pragmatic, and practical understanding of quantum computing: how it works, what makes it different from classical computing, what kinds of problems it may be useful for, and what kinds of problems it won’t be useful for.
- be able to judge the real-world impact of quantum computing today and in the coming years, as well as the challenges and opportunities it poses with respect to data security, simulation of complex systems, optimization problems, and AI/ML, to name a few examples
- be able to name and explain on a high level other quantum technologies (besides quantum computing) that may have a significant impact on the market, now or in the future
- be able to explain examples of business models in the area of quantum technology
- have had hands-on experience from working at challenges in developing business models in the quantum technology sector
- have had the chance to network and facilitate contacts with companies and experts at local research institutions and players in the local quantum technologies network

Quantum computing is a type of computing that uses quantum mechanics principles, such as superposition and entanglement, to process information. Unlike classical computers, which store information in bits (either 0 or 1), quantum computers use quantum bits, or qubits, which can exist in multiple states simultaneously. However, quantum computing is still in its early stages of development and faces significant challenges, such as maintaining the stability of qubits and minimizing errors due to environmental noise.

On day 1 of the 2-day course there will be introductory lectures to quantum computing and related quantum technologies such as quantum communication, quantum sensing, and quantum simulation by experts from academia. You will get an overview of Quantum mechanics, quantum computing algorithms as well as quantum hardware. In addition, we will offer lab tours where state-of-the-art quantum computing equipment can be seen in action, presented by scientists doing cutting-edge research at ETH Zurich.

Guest lectures from Swiss businesses in the field of quantum technologies will share their view on the current and future market and present their companies’ histories, strategies, and goals. Together we will discuss some of the current challenges facing quantum computing as well as potential future directions for research and development in this field.

On day 2, further guest lectures will present challenges on which the students can work in teams, followed by a final round of presentations and feedback.

The students will benefit from first-hand insights by experts in the field with diverse backgrounds (academic, startup, business, industrial). Grading (ungraded semester performance) is based on active participation on both days.

365-1083-00L Leading the Technology-Driven Enterprise

<table>
<thead>
<tr>
<th>Competencies</th>
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<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>- Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>- Social Competencies</td>
<td>Communication</td>
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<td>- Personal Competencies</td>
<td>Creative Thinking</td>
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<tr>
<td>365-1166-00L Learning Factory: Introduction to Lean and Industry</td>
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4.0 | Exclusively for MAS MTEC students (1st and 3rd semester).
A prior or parallel enrolment for the lecture “Production and Operations Management” (363-0445-00) is mandatory.

Abstract
This course (i) introduces the fundamentals of Lean Production and (ii) shows how new Industry 4.0 technologies can support a lean transformation. Through lectures, hands-on serious games, reflection and discussions, students learn (i) how lean production differs from other forms of production and (ii) how lean in synergy with new technologies can increase productivity in a production setting.

Objective
After taking this course, students will be able to:
1. Operationalize and apply lean principles in manufacturing
2. Design a production system that minimizes quality errors
3. Select and apply new Industry 4.0 technologies to support the lean transformation
4. Evaluate the challenges of implementing and scaling Industry 4.0 technologies
5. Work in a team to solve problems with selected problem-solving tools
6. Understand the role of behaviors and leadership in lean and Industry 4.0 transformations

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This course is organized as a block course with two full lecture days. Day 1 focuses on the fundamental lean production principles and practices. Students get intimately familiar with lean production through a hands-on and immersive serious game and integrated reflection rounds. Day 2 focuses on how new technologies challenge and enhance the classic lean principles through presentations, hands-on exercises, and discussions. After each day, students write reflection notes.

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>fostered</th>
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<tr>
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<td>Problem-solving</td>
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### Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Negotiation: fostered

### Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

### Content

**365-1059-00L Practicing Strategy**

- **W 1 credit 1S**

**Abstract**

This lecture is a special course for MAS students which supplements the Strategic Management course. Participants work on real-life strategy problems in a two-day workshop and apply concepts & methods from the Strategic Management course to develop suitable solutions.

**Objective**

The course has two goals. First, participants learn to decompose complex real life problems into underlying strategic issues. Second, students learn to transfer and use the concepts and methods from the Strategic Management course to develop solutions for the identified strategic issues in real-life business contexts.

**Content**

The course consists of two workshop days. However, most work for participants takes place in the phase between the two workshop days when participants engage in group work to solve a real-life strategic issue.

**First workshop day:**

Participants revisit core concepts and methods from the Strategic Management lecture. Moreover, participants learn the conceptual steps of defining strategic questions and developing suitable solutions for real-life settings. This conceptual process is then illustrated with an in-depth case study of a strategy consulting project that one of the lecturers conducted. The second part of the workshop day is the starting point for the group work phase. Participants identify a strategic problem that they face at work and team up (each group consists of 4-6 participants) to develop solutions by applying the concepts and methods from the Practicing Strategy class. At the end of the first workshop day, each group has defined one strategic question and developed a rough course of action for developing solutions until the second workshop day.

**Between workshop days:**

Participants work in small groups to develop solutions for the strategic problem that they identified on the first workshop day. This phase requires participants to select concepts and methods that are suitable to approach the strategic question. Moreover, students collect and analyze data. Subsequently, participants draw upon their analysis to develop solutions to the strategic problem. In this phase, participants can rely on the support and feedback from the teaching team.

**Second workshop day:**

Participants present their group work followed by an in-depth discussion and feedback session for each group project.

### Prerequisites / notice

- Successful registration and participation (either parallel enrollment or successful completion in a previous semester) in the course “Strategic Management” is required (see Course Catalogue page for details).

**Competencies**

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<td>Project Management</td>
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**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: assessed
- Negotiation: assessed

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

### 365-1183-00L Cases in Machine Learning

- **W 2 credits 1S**
- C. Cuchiero, A. Ferrario, J. Teichmann

**Abstract**

Machine learning has revolutionized various domains across industry sectors. Advances in GenAI has triggered this development and has created additional fantasies for future applications. Hence, an understanding its practical applications is crucial for professionals in today’s data-driven world. This course delves into the concepts of ML, its applications and use cases and ethical considerations.
After taking this course, participants will
- Understand the fundamental concepts of ML with some basic hands-on cases
- Understand and reflect on the ethical implications of ML algorithms, discuss bias, fairness, and transparency in AI systems
- Understand the concepts behind advances in deep learning and reinforcement learning, transformers
- Learn about applications of deep learning and reinforcement learning in finance
- Learn about key areas of AI in robotics, like computer vision, imitation learning, planning, robot control
- Get an overview of deep learning in different industries like logistics, automobile, healthcare
- Learn about the power and limits of LLMs
- Learn about prompt engineering, fine tuning and working with LLMs

Advancements in artificial intelligence (AI) have opened up exciting opportunities across various domains. In this lecture we explore the potential and hurdles in four key areas: machine learning, deep learning, reinforcement learning, and language models across different applications, with a focus on finance and robotics.

Day 1: Introduction to Machine Learning, Transparency, Interpretability and ethical aspects of ML

Day 2: Introduction to Deep Learning, Reinforcement Learning, Transformers, applications in finance and robotics, overview of deep learning across industries

Day 3: Focus on Large Language Models with Applications from prompt engineering and working with large language models in a business context

By the end of this course, students will have a comprehensive understanding of machine learning, its ethical dimensions, and practical applications.

The course is held in a workshop format with lecture and group work elements. Active participation on all course days is mandatory. Participants will work in groups on selected cases and have the opportunity to follow some basic coding examples in a Jupiter Notebook. Programming skills are not mandatory. An understanding of basic machine learning concepts is welcomed but also not mandatory (e.g. you took the class “Fundamentals on ML for Executives” or “AI for Executives”).

In the beginning of the course, we will do a short primer on mathematics and statistics and some fundamental aspects of machine learning to bring all students on the same level.

Grading (ungraded semester performance) is based on active participation in the class and a short written report (ungraded) after the course.

Subject-specific Competencies
- Concepts and Theories fostered
- Techniques and Technologies fostered
- Analytical Competencies fostered
- Media and Digital Technologies fostered
- Cooperation and Teamwork fostered
- Creative Thinking fostered
- Critical Thinking fostered

365-1142-00L Understanding Human Behavior - Research and Business Insights

W 1 credit 1V

Does not take place this semester.

Abstract
Human capital is the most precious resource of every company, while customers are the backbone of a company’s functioning. This course demonstrates application of behavioral science theories to improve decision making within the company and to better understand its customers. In this course, psychology meets finance, data science and analytics to address practical business problems.

Objective
The course objective is to provide a crash-course of behavioral economics and decision science with a special focus on aspects particularly important in business and international companies. The aim of the course will be to apply theoretical knowledge obtained during the classes at ETH in practical business cases stemming from ETH industry partners.

Content
This block course is divided into three components:
1. Theory Part: Students get familiar with the Nobel-Prize winning theories, key concepts, models and findings in decision science and behavioral economics. The covered topics include judgment and decision making, heuristics, biases and heuristics, nudges, psychometrics, risk appetite elicitation, digital and physiological footprints of decisions, and impact of emotions and environment on decisions. The material will be aligned with relevant real-life examples that relate to important societal and business problems. The students will be introduced to the behavioral study design, behavioral analytics and research methods that can be applied in a business environment accounting for its advantages and limitations.

2. Business Insights Part: In this part students learn how the behavioral aspects enter into business processes, workflows and customer relations. For the upcoming semester, Dr. Rafael Huber from Cablecom and ZHAW will join the course to give a workshop on agile working. The attendance of the second guest lecturer will be confirmed soon.

3. Application of Behavioural Insights: In this part, students will have the opportunity to go through various simulated cases and exercises.

Attendance during the meetings and solving the business case are mandatory requirements for successful completion of the course. Course material includes the lecture slides and scientific papers.

The course consist of five sessions taking place on weekdays during after-work hours. The course includes two guest speakers working in an applied field of behavioral sciences and several cases and (reflective) exercises. Discussed topics include complex decision-making, individual resilience, risk, forecasting techniques, human-technology interaction, methodology of behavioral interventions and studies.

The course has a form of an interactive lecture where discussions and exchanges are welcome.

There is no mandatory literature for this course. Additional reading will be distributed during the course.

This course is open to all third-semester students of the Master of Advanced Studies of Management and Technology, ETH Zurich.


### Competencies

**Subject-specific Competencies**
- Concepts and Theories 
- Techniques and Technologies 

**Method-specific Competencies**
- Analytical Competencies 
- Decision-making 
- Problem-solving 

**Social Competencies**
- Communication 
- Cooperation and Teamwork 
- Customer Orientation 
- Leadership and Responsibility 
- Self-presentation and Social Influence 
- Sensitivity to Diversity 

**Personal Competencies**
- Negotiation 
- Adaptability and Flexibility 
- Creative Thinking 
- Critical Thinking 
- Self-awareness and Self-reflection 
- Self-direction and Self-management 

### Abstract

Alliances within innovation ecosystems are essential for developing new business models that address the increasing complexity of technologies and systems, as well as the intensifying global competition. Organizations are compelled to prioritize selected partnerships for value creation. We will emphasize the role of alliances and collaborations in driving innovation within these ecosystems.

### Objective

**Learning outcomes professional competence**
- Learn and understand the management basics of inter-firm collaboration and organizational networks (strategy considerations incl. collaborative business models; cultural aspects including both corporate culture and international aspects, risk management, communication, etc.)
- Realize the value creation potentials of alliances (added value)
- Understand underlying theoretical models (mainly from the institutional economics, focusing on transaction cost and principal agent theory)
- Identify and understand specific forms of collaboration (strategic alliances, joint ventures, Networks, etc.)
- Apply tools hands on in real companies (planned in collaboration with companies)

**Learning outcomes methodological competence**
- Writing academic papers
- Developing structured documentation of interviews (in form of a presentation)
- Transferring theory directly into practical application
- Contributing to the learning journey

**Learning outcomes social competence**
- Improving communication skills as basics for collaboration
- Developing and applying teamwork skills
- Work together with industrial partners
- Coping with conflicts resolution in teams

### Content

The ever-increasing complexity of technologies and systems, coupled with heightened competitive pressure and the need to shorten time-to-market, drives organizations to concentrate on their core competencies. Collaborating with external partners presents a crucial value creation opportunity, significantly impacting daily management activities. This lecture aims to provide a comprehensive understanding of the unique management requirements for successful cooperation.

**Content:**
- Introduction to the theory and management of inter-firm collaboration and networks.
- Examination of the formation, management, and evolution of collaborations and networks.
- Examplary collaborations in marketing, development, and manufacturing.
- Special forms of collaborations: innovation ecosystems, strategic alliances, joint ventures, Networks, etc.

**Learning Journey:**
- Introductory day providing an overview of the theoretical framework, explaining the course concept, case study(ies) and intro to the first assignment.
- First assignment focusing on key aspects of the framework: Networked Business Strategies; Culture and People Orientation; Leadership, Interaction and Communication; Resilience, Risk and Trust; Agile Structures and Processes; Collaborative Skills Development.
- Preparation for the second assignment.
- Second Assignment: Analysis of real alliance projects within partner companies, i.e. preparing and conduction an interview, summarizing the interview into a presentation.
- Final day: Best practice exchange session to conclude the course.

This structured approach ensures a thorough understanding of inter-firm collaboration management, equipping participants with the necessary skills to navigate and leverage these partnerships effectively.

### Literature

- Classic Books:
  - HBR Collaborating Effectively ISBN 978-1-4221-6384-4
  - HBR on Mergers and Acquisitions: ISBN 1-57851-555-6

### Prerequisites / notice

The number of students participating in the lecture is limited to 30.
The seminar "Cases in Technology Marketing" introduces students to key concepts and tools in technology marketing and familiarizes them subsequently with the challenges that (marketing) managers face in technology intensive markets by using real life cases.

**Analytical Competencies**
1. Understanding and applying common business tools and frameworks
2. Understanding current challenges of managers in technology-intensive markets
3. Defining and analyzing comprehensive business problems using the example of a leading Swiss manufacturing company (Bühler AG)
4. Developing and evaluating different alternative case solutions
5. Making decisions on case solutions, justifying and defending them
6. Transferring case solutions into practice by formulating specific instructions for the management
7. Creation of novel, innovative ideas that help the company to gain a competitive edge
8. Cooperation in teams and coordination of team tasks
9. Adequate communication to and eye-level discussions with C-level managers

**Method-specific Competencies**

**Social Competencies**

**Personal Competencies**

**Competencies**

**Subject-specific Competencies**

**Method-specific Competencies**

**Social Competencies**

**Personal Competencies**

**Prerequisites / notice**

Students have to apply for this course by sending a CV and an one-page motivation letter until 31.8.2023 to Theresa Schachner: tschachner@ethz.ch.

Additionally please enroll via myStudies. Places will be assigned on the basis of your motivation letter.

**Abstract**

The seminar “Cases in Technology Marketing” introduces students to key concepts and tools in technology marketing and familiarizes them subsequently with the challenges that (marketing) managers face in technology intensive markets by using real life cases. Students will have to work in groups and together solve past, current and future managerial problems in the form of cases. The team member composition will rotate for each case, enabling students to foster their teamwork abilities besides the application of theoretical concepts to the applied case questions. The students will have to present their case solutions to the lecturer and a top executive of a leading Swiss company (details see below). Also, they will be enabled to compare their solutions with what has actually been done or is yet to be done.

The three case studies presented in this course cover real managerial issues of the Swiss manufacturer Bühler AG (www.buhlergroup.com). A Bühler top executive will present the cases and discuss the students’ presentations and solutions. As such, the course allows for in-depth discussions of the real-life case solution with the C-level manager and hereby enables students to transfer their learnings from theoretical considerations to the applied field. The course will be rounded off with a day visit to the Bühler facilities in Uzwil, Switzerland, where students will have the chance to further connect with management and discuss the acquired key concepts, tools, and case study insights on-site.

**In addition to course enrolment, students have to apply for this course by sending a CV and a short motivation letter until 31.08.2023 to Dr. Theresa Schachner: tschachner@ethz.ch.**

**Content**

The seminar “Cases in Technology Marketing” introduces students to key concepts and tools in technology marketing and familiarizes them subsequently with the challenges that (marketing) managers face in technology-intensive markets by using real-life cases. Students will have to work in groups and together solve past, current and future managerial problems in the form of cases. The team member composition will rotate for each case, enabling students to foster their teamwork abilities besides the application of theoretical concepts to the applied case questions. The students will have to present their case solutions to the lecturer and a top executive of a leading Swiss company (details see below). Also, they will be enabled to compare their solutions with what has actually been done or is yet to be done.

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**Prerequisites / notice**

In addition to course enrolment, students have to apply for this course by sending a CV and a short motivation letter until 31.08.2023 to Dr. Theresa Schachner: tschachner@ethz.ch.
The course is a combination of lectures about concepts/methods, guest lectures, case studies, and individual assignments.

Large- and medium-sized corporations play a central role in the economic activity of most developed and developing countries. Many of these organizations perform multiple business activities in multiple markets. In the face of increasing international competition, globalization, technological development, deregulation, and the emergence of new markets and industries, operating such a portfolio of business activities poses important managerial challenges forcing corporations to continuously re-consider their vertical and horizontal scope and boundaries.

The course Corporate Strategy draws from a wide range of theories and methods to develop an understanding of the conceptual frameworks, debates, and developments concerning decisions associated with the management of multi-business corporations. We will cover the key questions driving a firm's corporate strategy, including:

- In what markets to compete with which businesses?
- Which activities should be performed by the firm and which should be outsourced (i.e. "make" or "buy" decisions)?
- What are the most appropriate approaches to growth and divestiture?
- How do institutional forces impact corporate strategy?

Specifically, we will examine how organizations manage their portfolio of business activities and markets to achieve competitive advantage through vertical integration, cooperative strategies such as strategic alliances and joint ventures, corporate diversification, mergers and acquisitions, divestitures, and globalization/international strategies, and strategic renewal.

The course homepage can be found at: http://www.smi.ethz.ch/education/corporate-strategy.html

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers.

3 credits

Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed
Problem-solving assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management assessed

363-1163-00L Developing Digital Biomarkers

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in many different areas. To derive clinical meaningful information from these data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current and emerging challenges.

Prerequisites / notice
Having participated in the course Strategic Management by Prof. Georg von Krogh/Dr. Stephan Herting is an advantage but not a requirement.

The course has four core learning objectives. Students should:

• understand the anatomy of digital biomarkers
• understand the potential and applications of digital biomarkers
• be able to critically reflect and assess existing digital biomarkers
• be able to design and implement a digital biomarker

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer-centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current and emerging challenges.

Literature

Method-specific Competencies

Literature

Personal Competencies

Critical Thinking assessed
Self-direction and Self-management assessed

Specifically, we will examine how organizations manage their portfolio of business activities and markets to achieve competitive advantage through vertical integration, cooperative strategies such as strategic alliances and joint ventures, corporate diversification, mergers and acquisitions, divestitures, and globalization/international strategies, and strategic renewal.

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2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer-centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

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Prerequisites / notice

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• understand the potential and applications of digital biomarkers
• be able to critically reflect and assess existing digital biomarkers
• be able to design and implement a digital biomarker

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

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#### 363-1082-00L Enabling Entrepreneurship: From Science to Startup

Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

**Abstract**

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

**Objective**

Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs.
2. The students can be from business or science & technology.
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea.

**Content**

The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders’ agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

**Lecture notes**

Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

**Literature**

- **Book**
  - Sethi, A. “From Science to Startup”
  - ISBN 978-3-319-30422-9

**Prerequisites / notice**

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.
Entrepreneurial Leadership

363-1028-00L

W 4 credits 3S

Z. Erden Özkol, S. Brusoni, O. von Dzengelevski, G. von Krogh

Abstract

This seminar provides master and PhD students at MTEC with the challenging opportunity of a real case on strategy, innovation and leadership in close collaboration with the senior management of a leading company: UBS.

Objective

The general objective of the course is to enable MTEC students to develop leadership skills by dealing with real-world business problems, thinking critically about the concepts discussed in their study programs and learning how to apply these concepts to provide practical implications. It provides students with coaching and mentoring from senior leaders in the company and professors from D-MTEC to bridge the gap between theory and practice.

Content

This seminar provides ambitious ETH students and doctoral candidates with a rewarding learning opportunity: a real case study of strategy and innovation in close collaboration with the top management of an outstanding company: UBS.

What you can expect:

You will work in teams on specific high priority assignments that flow from the company. Delving into the assignments you will both contribute to solving strategic issues and have an impact on their implementation at the company.

To gain insight into the company and its culture you will receive briefings from senior management, conduct interviews with experts and run workshops with your case managers. In the final presentations you will pitch your findings to key stakeholders and top management representatives and receive valuable feedback.

Furthermore you will be coached and supported by MTEC professors on the topics of project scoping, problem definition and solving, process improvement, strategy and board presentation.

The course is directed and organized by PD. Dr. Zeynep Erden and Dr. Isabel Spicker as part of the MTEC Leadership Development Programme.

What we expect from you:

You are an ambitious ETH student or doctoral candidate who is looking for a rewarding learning opportunity and is eager to go the extra mile. You will work on a real case study of strategy, technology and innovation in close collaboration with the senior management of an outstanding company. The recommendations that you formulate in collaboration with members of your team as well as with internal and external experts will be discussed at the partner and director levels. This demands a deep understanding of the company’s leadership culture.

In this endeavour, you are coached and supported by

- Stefano Brusoni, Chair of Technology and Innovation Management
- Georg von Krogh, Chair of Strategic Management and Innovation
- Oliver von Dzengelevski, Chair of Production and Operations Management
- Zeynep Erden, Lecturer, D-MTEC
- Isabel Spicker, D-MTEC

Literature

Literature and readings will be announced in the coaching sessions.

Prerequisites / notice

Please apply for this course via the official website (https://mtec.ethz.ch/studies/programme-elements/special-programmes/els.html). Apply no later than August 18, 2024.

The number of participants is limited to 18.

ECTS: 4

Participants receive a certificate.
<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Personal Competencies</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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**Management Research**

W 1 credit 1S U. Stettner

**Abstract**
Students learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop their own research projects.

**Objective**
You will learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop your own research project. The successful completion of the course will help you to:
- Think critically and make compelling arguments about the strengths and weaknesses of published management research
- Find and review appropriate literature and previous research for your thesis
- Develop and frame interesting and relevant research questions and problem statements
- Design your research and choose an appropriate methodology for analysis (specific research methods and techniques are not discussed in this course)
- Structure your manuscript
- Plan and manage your thesis project

**Content**
This course combines lectures, group discussions and individual assignments.

Day 1: Course introduction, group analysis exercises and discussions, lectures on main topics.
Between course days 1 and 2: Individual and group work on assignments.
Day 2: Assignment review and discussion, lectures on main topics, conclusion session.

**Target audience:**
The course is designed with two groups of students in mind: first, students who write their master thesis at the SMI chair and second, students who write their master thesis in the field of management at other MTEC chairs.
For both groups, the focal topics of this course will arise frequently during the journey of writing their thesis, and the majority of topics are relevant for all students. However, we will provide some specific content (grading guidelines, thesis format) which might not be applicable for students tutored at other MTEC chairs.

**Course topics:**
1. Thesis topic and thesis proposal:
   - Choice of thesis topic, identification of research gap, formulation of research questions, writing of thesis proposal
2. Literature review:
   - Search and evaluation of academic literature, use of reference tools, writing of theoretical background chapter of thesis
3. Empirical research design:
   - Types of empirical research designs, choice of methodology, overview of data collection and analysis methods
4. Research output and report:
   - Writing of introduction, results and conclusion, thesis format and structure
5. Thesis assessment:
   - SMI grading criteria, MTEC guidelines

**References:**

**Prerequisites / notice**
This course is for all students who write their master thesis at the Department of Management, Technology, and Economics.
The course is required for all M.Sc. students and MAS students who write their master thesis at the Chair of Strategic Management and Innovation.
The course is graded based on the assignments, peer feedback, and participation in group discussions.
The first assignment is due before the first course day. Please check the assignments on the Moodle coursepage. If you sign up for the course on short notice before the first course day, please advise the lecturer of your registration by email.
Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Media and Digital Technologies

Social Competencies

Communication
Cooperation and Teamwork

Personal Competencies

Critical Thinking
Integrity and Work Ethics
Self-direction and Self-management

H. Schernberg

There is no script, but slides will be made available before the lectures.

Subject-specific Competencies

2G - You know how risk and risk management is defined and applied in different industries

Analytical Competencies

W - assessed

The course covers the economics of risk and insurance, in particular the following topics will be discussed:

2V - assessed

- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

Communication

N. Bienefeld-Seall

Objective

This course consists of three main elements:

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).

Content

The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  o Risk identification and evaluation
  o Risk mitigation
  o Risk communication

- Psychological and organizational concepts relevant in risk management
  o Decision-making under uncertainty
  o Risk perception
  o Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

- Group projects related to company case studies

Lecture notes

There is no script, but slides will be made available before the lectures.

Literature

There are texts for each of the course topics made available before the lectures.

Prerequisites / notice

The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

Competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Social Competencies

Communication
Cooperation and Teamwork

Personal Competencies

Adaptability and Flexibility
Creative Thinking

R. Schneider, M. Zumbühl

363-1017-00L

Risk and Insurance Economics

W 3 credits 2G H. Schernberg

Abstract

The course covers the economics of risk and insurance, in particular the following topics will be discussed:

- Individual decision making under risk
- Models of insurance demand, risk sharing, insurance supply
- Information issues in insurance markets
- Advanced topics in microeconomics and behavioral economics
- The macroeconomic role of insurers and insurance regulation

Objective

The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1;

Further readings:

References will be given on a topic-by-topic basis during the course.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered

Personal Competencies
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

Lecture notes
Slides will be available on the Moodle page

Literature
Readings will be available on the Moodle page

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics
Climate change is on par with political instability, violent conflicts, cybersecurity, and volatile interest rates. However, there is one exception - extreme weather, driven in concert with a changing climate, will continue to evolve and become increasingly severe over time. It is vital to foster the ability to anticipate and address extreme weather-related challenges, related challenges, and to equip business leaders to navigate the intersection of climate risk and sustainability. The course introduces climate risk modelling and how to derive business decisions from it, to identify and assess sustainability in the current regulatory environment.

As extreme weather, driven in concert with a changing climate, will continue to evolve and become increasingly severe over time, it is essential to foster the ability to anticipate and address extreme weather-related challenges, related challenges, and to equip business leaders to navigate the intersection of climate risk and sustainability. This course introduces climate risk modelling and how to derive business decisions from it, to identify and assess sustainability in the current regulatory environment.

Climate Risk and Sustainability in Finance and Insurance
Exclusively for MAS MTEC students (3rd semester).
Please register by 02.09.2024 at the latest via myStudies.

The course is offered as a block course, allowing for a workshop character. Students will work in groups on selected cases on each day and share their thoughts and findings with industry professionals. Participation on all course days is mandatory. Performance assessment is based on active contribution and presentation of group work and cases.

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The course is not targeted to participants with a background and work experience in the finance, banking, or insurance sector only. This course will benefit from participants with diverse backgrounds and industry experience.

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The course is not targeted to participants with a background and work experience in the finance, banking, or insurance sector only. This course will benefit from participants with diverse backgrounds and industry experience.
This course is designed to help you understand what plagiarism is and how to avoid it. The key features of the course include:
- Interviews with students and tutors sharing their thoughts on plagiarism
- Key terms and different types of plagiarism explained
- Interactive activities to help you learn what plagiarism is
- Interactive activities to help you practise how to correctly cite and reference different sources
- Strategies to help you develop an action plan to avoid plagiarism
- Online resources to help extend your learning, including articles on real-life cases of plagiarism.

**Content**

**Prerequisites / notice**

Plagiarism guidelines defined by ETH Zurich are authoritative.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Details</th>
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<tr>
<td>365-0899-00L</td>
<td>Master's Thesis in a Company</td>
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</table>

**Abstract**

In the Master's thesis students prove their ability to independent, structured and scientific working.

**Objective**

In the Master's thesis students prove their ability to do independent, structured and scientific work. The Master's thesis is written in collaboration with an industrial partner, organisation or institution and is supervised by an MTEC professor and a company supervisor.

**Company supervisor:**
The Master's thesis is written in collaboration with an industrial partner, organisation or institution (all of which may be referred to as a company in the following). A company employee acts as external supervisor for the Master's thesis.

**Supervising professor:**
In addition to a company supervisor, you need a D-MTEC professor to serve as the main supervisor of your thesis.

**Prerequisites / notice**

You have to fulfil the following requirements before you can register for a Master's thesis:

- You must have passed the “365-1170-00L Epigeum’s Avoiding Plagiarism Online Course” which covers anti-plagiarism topics and citation rules in your 1st semester of study. Handling the intellectual property of others is not only an integral part of the Master’s thesis, but also a part of every semester paper you will write at ETH.

- You must have read the “Citation Etiquette” information sheet on plagiarism (https://ethz.ch/content/dam/ethz/special-interest/study-programme-websites/mas-mtec-dam/Education/education-files/Citation%20etiquette%20-%20plagiarism-citationetiquette.pdf)

**MAS in Management, Technology, and Economics - Key for Type**

<table>
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<tr>
<th>Key</th>
<th>Compulsory</th>
<th>Eligible for credits and recommended</th>
<th>Eligible for credits</th>
<th>Recommended, not eligible for credits</th>
<th>Courses outside the curriculum</th>
<th>Suitable for doctorate</th>
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**Key for Hours**

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<td>colloquium</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Medical Physics

Compulsory Courses (for both Specialisations)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>465-0953-00L</td>
<td>Anatomy and Physiology for Medical Physicists I</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>F. Kuhn</td>
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<tr>
<td>Abstract</td>
<td>Introduction to structure and function of the human body. The lectures will be based on current clinical practices in Radiology, Neuroradiology and Nuclear Medicine.</td>
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<tr>
<td>Objective</td>
<td>Physiological and anatomical knowledge of the human body to ensure the correct understanding of basic concepts and to facilitate the collaboration of medical physicists and other health professionals.</td>
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<tr>
<td>Content</td>
<td>'Anatomy and physiology for medical physicists I &amp; II' provides insights into structure and function of the human body. The content is presented in an accessible manner targeted to physicist working in a medical environment. The lectures will be based on current clinical practices in Radiology, Neuroradiology and Nuclear Medicine. After an introduction to cells and tissues the following systems will be addressed: 1) Support &amp; Movement (musculoskeletal system, biomechanics); 2) Neuroscience (central and peripheral nervous system); 3) Auto-regulation (endocrine system) &amp; Internal Transport (blood &amp; cardiovascular system); 4) Environmental Exchange (respiratory, urinary, digestive &amp; reproductive system).</td>
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<tr>
<td>465-0966-00L</td>
<td>Biostatistics</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>B. Sick</td>
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<tr>
<td>Abstract</td>
<td>The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests, measurement of agreement, causality versus association.</td>
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<td>Objective</td>
<td>- know the commonly used methods in biostatistics</td>
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<td>- perform simple data analysis with R</td>
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<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>O</td>
<td>6</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüssmann</td>
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<tr>
<td>Abstract</td>
<td>Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.</td>
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<td>Objective</td>
<td>Upon completion of the course students are able to:</td>
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<td>• Explain the physical and mathematical foundations of diagnostic medical imaging systems</td>
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<td>• Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function</td>
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<td>• Design a basic diagnostic imaging system chain including data acquisition and data reconstruction</td>
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<td>• Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications</td>
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<td>• Introduction (intro, overview, history)</td>
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<td>• Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)</td>
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<td>• X-rays (production, tissue interaction, contrast, modular transfer function)</td>
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<td>• X-rays (resolution, detection, digital subtraction angiography, Radon transform)</td>
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<td>• X-rays (filtered back-projection, spiral computed tomography, image quality, dose)</td>
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<td>• Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PEPT)</td>
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<td>• Nuclear imaging (detection principles, image reconstruction, kinetic modelling)</td>
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<td>• Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)</td>
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<tr>
<td></td>
<td>• Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)</td>
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<tr>
<td></td>
<td>• Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)</td>
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<tr>
<td></td>
<td>• Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)</td>
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<tr>
<td></td>
<td>• Ultrasound (spatial and temporal resolution, phased arrays)</td>
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<td></td>
<td>• Ultrasound (Doppler shift, implementations, applications)</td>
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<td></td>
<td>• Summary, example exam questions</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes and handouts</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>Webb A, Smith N.B. Introduction to Medical Imaging; Physics, Engineering and Clinical Applications; Cambridge University Press 2011</td>
<td></td>
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<tr>
<td>Prerequisites / notice</td>
<td>Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
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<td></td>
<td>Concepts and Theories</td>
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<td></td>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
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<td></td>
<td>Social Competencies</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-direction and Self-management</td>
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<tr>
<td>465-0953-00L</td>
<td>Physics in Radiodiagnostic and Nuclear Medicine</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>F. Bochud</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course is dedicated to introduce MAS students from Medical Physics to the field of radiodiagnostic and nuclear medicine. Dedicated practicals will illustrate the theory with an emphasis on the relationship between dose and image quality as well as the security problems related to the work with radiations.</td>
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<tr>
<td>Objective</td>
<td>This 1-week theory and practical class offers the possibility to enjoy a variety of research and clinical areas in diagnostic and nuclear medicine. It gives insight into practical concepts and techniques that are discussed thoroughly as the class is performed within actual laboratories with real radiation sources.</td>
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</table>
The purpose of this course is to impart basic knowledge in radiobiology in order to handle ionizing radiation and to provide a basis for understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiotherapy, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Specialisation in Radiation Therapy

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>O</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manen</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and radiological consequences. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.</td>
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</tr>
<tr>
<td>Content</td>
<td>The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiotherapy, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.</td>
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</tbody>
</table>

Prerequisites / notice
- For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

Competencies
- Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

227-0943-00L | Radiobiology | O | 2 | 2V | M. Pruschy |
| Abstract     | The purpose of this course is to impart basic knowledge in radiobiology in order to handle ionizing radiation and to provide a basis for predicting the radiation risk. |
| Objective    | By the end of the course the participants will be able to: |
| a) interpret the 6 Rs of radiobiology in the context of the hallmarks of cancer |
| b) understand factors which underpin the differing radiosensitivities of different tumors |
| c) follow rational strategies for combined treatment modalities of ionizing radiation with targeted and immunological agents |
| d) understand differences in the radiation response of normal tissue versus tumor tissue |
| e) understand different treatment responses of the tumor and the normal tissue to differential clinical-related parameters of radiotherapy (dose rate, LET etc.). |
| Content      | Einführung in die Strahlenbiologie ionisierender Strahlen: Allgemeine Grundlagen und Begriffsbildungen; Mechanismen der biologischen Strahlenwirkung; Strahlenwirkung auf Zellen, Gewebe und Organe; Modifikation der biologischen Strahlenwirkung; Strahlenzytogenetik: Chromosomenveränderungen, DNA-Defekte, Reparaturprozesse; Molekulare Strahlenbiologie: Bedeutung inter- und intrazellulärer Signalübermittlungsprozesse, Strahlen-induzierter Zelltod, Zellzyklus-Checkpoints; Radioimmunologie, Strahlenrisiko; Strahlensyndrome, Krebsinduktion, Mutationsauslösung, pränatale Strahlenwirkung; Strahlenbiologische Grundlagen des Strahlenschutzes; Nutzen-Risiko-Abwägungen bei der medizinischen Strahlenanwendung; Prädiktive strahlenbiologische Methoden zur Optimierung der therapeutischen Strahlenanwendung. |
| Literature   | Beilagen mit zusammenfassenden Texten, Tabellen, Bild- und Grafikdarstellungen werden abgegeben. |
| Lecture notes | Literaturliste wird abgegeben. |
| Prerequisites / notice | The former number of this course unit is 465-0951-00L. |

Competencies
- Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed

Practical Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>465-0956-00L</td>
<td>Dosimetry</td>
<td>O</td>
<td>4</td>
<td>6G</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>Dosimetry in radiotherapy. Planning and implementation of a percutaneous radiation exposure on an anthropomorphic phantom. Verification of the resulting dose distribution.</td>
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<tr>
<td>Objective</td>
<td>Praktische Umsetzung der Lerninhalte der Vorlesungen Medizinphysik I &amp; II bezüglich Dosimetrie bei perkutanen Strahlenexpositionen</td>
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<tr>
<td>Content</td>
<td>Überprüfung der resultierenden Dosisverteilungen.</td>
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<tr>
<td>Lecture notes</td>
<td>Die Kursunterlagen werden im Blockkurs abgegeben.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Voraussetzung: Besuch der Vorlesung Medizinische Physik I</td>
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</tbody>
</table>

Competencies
- Subject-specific Competencies
- Concepts and Theories assessed

Specialisation in General Medical Physics

Major in Radiation Therapy
## Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manser</td>
</tr>
</tbody>
</table>

### Objective
- Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefit of patients and the society.

### Content
- The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

### Lecture notes
- A script will be provided.

### Prerequisites / notice
- For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

### Competencies
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies

## Practical Work

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
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<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manser</td>
</tr>
</tbody>
</table>

### Objective
- Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefit of patients and the society.

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### Lecture notes
- A script will be provided.

### Prerequisites / notice
- For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

### Competencies
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies

## Electives

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<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manser</td>
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</tbody>
</table>

### Objective
- Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefit of patients and the society.

### Content
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### Lecture notes
- A script will be provided.

### Prerequisites / notice
- For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

### Competencies
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1690 of 2667
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes
Available online

Literature
Will be indicated during the lecture.

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>227-0941-00L</td>
<td>Physics and Mathematics of Radiotherapy Planning (University of Zurich)</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: PHY471</td>
<td><a href="https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html">https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html</a></td>
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</table>

Abstract
This lecture will provide a detailed introduction to radiotherapy treatment planning. The course considers the physical interactions of radiation in tissue, the mathematical aspects of treatment planning and additional aspects of central importance for radiotherapy planning.

Objective
Students shall develop a thorough understanding of the foundations of radiotherapy from a physics and mathematics perspective, focusing on algorithmic components. After completing the course students should be able to implement the main components of a radiotherapy treatment planning system.

Content
Radiotherapy is one of the main treatment options against cancer. Today, more than 50% of cancer patients receive radiation as part of their treatment. Modern radiotherapy is a highly technology driven field.

Research and development in medical physics has improved the precision of radiotherapy substantially. Using intensity-modulated radiotherapy (IMRT), radiation can be delivered precisely to tumors while minimizing radiation exposure of healthy organs surrounding the tumor. Thereby, medical physics has provided radiation oncologists with new curative treatment approaches where previously only palliative treatments were possible. This lecture will provide a detailed introduction to radiotherapy treatment planning and will consists of three blocks:

1. The first part of the course considers the physical interactions of radiation in tissue. The physical interactions give rise to dose calculation algorithms, which are used to calculate the absorbed radiation dose based on a CT scan of the patient.

2. The second part considers the mathematical aspects of treatment planning. Mathematical optimization techniques are introduced, which are used in intensity-modulated radiotherapy to determine the external radiation fields that optimally irradiate the tumor while minimizing radiation dose to healthy organs.

3. The third part deals with additional aspects of central importance for radiotherapy planning. This includes biomedical imaging techniques for treatment planning and target delineation as well as image registration algorithms.

The lectures are followed by computational exercises where students implement the main components of a radiotherapy treatment planning systems in two dimensions in Matlab.

Lecture notes
Lecture slides and handouts.

Prerequisites / notice
Basic programming skills in Matlab (or willingness to learn) are needed for the exercises. Basic knowledge of calculus is needed, approximately corresponding to the 3rd year of a bachelor degree in physics, mathematics, computer science, engineering or comparable discipline.

402-0674-00L | Physics in Medical Research: From Atoms to Cells | W | 6 credits | 2V+1U | B. K. R. Müller |

Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxide and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure’s shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s anisotropies of biospies.

### Major in Biomechanics
### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**

- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.

**Lecture notes**

- Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino
- AND

**Prerequisites / notice**

- No specific requirements, BUT
- ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Leadership and Responsibility: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### 227-0965-00L Micro and Nano-Tomography of Biological Tissues

<table>
<thead>
<tr>
<th>Credits</th>
<th>Lecture hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3G</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

**Objective**
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

**Content**

- Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

- The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

- The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

**Lecture notes**
Available online

**Literature**
Will be indicated during the lecture.

### 376-1651-00L Clinical and Movement Biomechanics

<table>
<thead>
<tr>
<th>Credits</th>
<th>Lecture hours</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>3G</td>
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</table>

**Abstract**
Measurement and modeling of the human movement during daily activities and in a clinical environment.

**Objective**
The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

**Content**
This course includes study design, measurement techniques, clinical testing, accessing movement data and analysis as well as modeling with regards to human movement.

### 376-1985-00L Trauma Biomechanics

<table>
<thead>
<tr>
<th>Credits</th>
<th>Lecture hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2V+1U</td>
</tr>
</tbody>
</table>

**Abstract**
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

**Objective**
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

**Lecture notes**
Handouts will be made available.

**Literature**
### Competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed

**Social Competencies**
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### Practical Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>465-0800-00L</td>
<td>Practical Work</td>
<td>O</td>
<td>4</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

**Abstract**
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

**Objective**
The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

### Electives

<table>
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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0524-00L</td>
<td>Continuum Mechanics I</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>A. E. Ehret</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

**Objective**
After successful completion of the course the student are able to
- explain basic theories for solving continuum mechanics problems
- proficiently apply these theories by solving application-related academic examples
- relate the theories and examples to real engineering applications and challenges
- distinguish between different mechanical behaviors of materials
- systematically select appropriate constitutive theories suitable to analyze and model these materials

**Content**
Anisotropic Elasticity, Linear Elastic and Linear Viscous Material Behavior, Viscoelasticity, Micro-Macro Modelling, Lamine Theory, Plasticity, Viscoplasticity, Examples of Engineering Applications, Comparison with Experiments

**Lecture notes**
yes

**Competencies**
- Subject-specific Competencies: Concepts and Theories, assessed
- Method-specific Competencies: Analytical Competencies, assessed
- Personal Competencies: Creative Thinking, fostered

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
</tbody>
</table>

**Abstract**
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

**Content**
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

**Lecture notes**
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

**Prerequisites / notice**
The lecture will be taught in English.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-2017-00L</td>
<td>Biomechanics of Sports Injuries and Rehabilitation</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>K.-U. Schmitt, J. Goldhahn</td>
</tr>
</tbody>
</table>

**Abstract**
This lecture introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries.

**Objective**
Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.
This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.

Handouts will be made available.


A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1721-00L</td>
<td>Bone Biology: Basics, Research and Clinics</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>E. Wehrle, G. A. Kuhn, to be announced</td>
</tr>
</tbody>
</table>

The course gives an introduction into bone biology and provides an overview on current research methods and clinical approaches. Emphasis is put on skeletal development and metabolism, osteoporosis as well as fracture healing. Each topic is structured into three parts: basics, research and clinics.

After completing the Bone Biology course, students will be able to:
(1) Remember and apply basics in bone biology and disease
(2) Remember clinical features and surgical approaches
(3) Select adequate research methods and approaches
(4) Evaluate publications on topics presented in the lecture

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories assessed</td>
<td>Analytical Competencies assessed</td>
<td></td>
<td>Adaptability and Flexibility fostered</td>
</tr>
<tr>
<td></td>
<td>Techniques and Technologies fostered</td>
<td>Decision-making fostered</td>
<td>Communication fostered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analytical Competencies</td>
<td>Media and Digital Technologies fostered</td>
<td>Cooperation and Teamwork assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decision-making fostered</td>
<td>Problem-solving fostered</td>
<td>Leadership and Responsibility fostered</td>
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<tr>
<td></td>
<td>Media and Digital Technologies fostered</td>
<td>Problem-solving fostered</td>
<td>Self-presentation and Social Influence fostered</td>
<td></td>
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<tr>
<td></td>
<td>Decision-making fostered</td>
<td>Project Management fostered</td>
<td>Sensitivity to Diversity fostered</td>
<td></td>
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<tr>
<td></td>
<td>Media and Digital Technologies fostered</td>
<td></td>
<td></td>
<td>Adaptability and Flexibility fostered</td>
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<tr>
<td></td>
<td>Decision-making fostered</td>
<td></td>
<td></td>
<td>Creative Thinking fostered</td>
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<tr>
<td></td>
<td>Decision-making fostered</td>
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<td>Critical Thinking assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making fostered</td>
<td></td>
<td></td>
<td>Integrity and Work Ethics assessed</td>
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<tr>
<td></td>
<td>Decision-making fostered</td>
<td></td>
<td></td>
<td>Self-awareness and Self-reflection fostered</td>
</tr>
<tr>
<td></td>
<td>Decision-making fostered</td>
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<td></td>
<td>Self-direction and Self-management fostered</td>
</tr>
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</table>

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

History of BME and the role of biomedical engineers. Ethical issues related to BME. Biomedical sensors both wearable and also biochemical sensors. Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices. Bioinformatics: genomic and proteomic tools, databases and basic calculations. Equations describing basic reactions and enzyme kinetics. Medical optics: Optical components and systems used in hospitals. Basic concepts of tissue engineering and organ printing. Biomaterials and their medical applications. Function of the heart and the circulatory system. Transport and exchange of substances in the human body, compartment modeling. The respiratory system. Bioimaging. Orthopedic biomechanics. Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

Introduction to Biomedical Engineering

by Enderle, Banchard, and Bronzino

AND

Introduction to Biomedical Engineering

by Enderle, Banchard, and Bronzino

No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected

### Analytical Competencies

<table>
<thead>
<tr>
<th>Title</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image Analysis and Computer Vision</td>
<td>6</td>
<td>2V+1U</td>
<td>E. Konukoglu, E. Erdil, F. Yu</td>
</tr>
</tbody>
</table>

**Abstract**


**Objective**

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Course material** Script, computer demonstrations, exercises and problem solutions

**Lecture notes**

Course material Script, computer demonstrations, exercises and problem solutions

**Prerequisites / notice**

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

### Practical Work

**Number**

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>Practical Work</td>
<td>O</td>
<td>4</td>
<td>external organisers</td>
<td></td>
</tr>
</tbody>
</table>

**Abstract**

The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

**Objective**

The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

### Electives

**Number**

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<thead>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro and Nano-Tomography of Biological Tissues</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Stampalone, F. Marone Welford</td>
</tr>
</tbody>
</table>

**Abstract**

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

**Objective**

Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

**Content**

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

**Lecture notes**

Available online

**Literature**

Will be indicated during the lecture.
This seminar teaches problem solving skills for computational neuroimaging, based on analyses of neuroimaging and behavioural data. It covers all aspects of statistical parametric mapping (SPM), including preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM). A Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

Objective
To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), including preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM). A Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

Prerequisites
The participants are expected to have successfully completed at least one of the following courses:
- Methods & models for fMRI data analysis
- Translational Neuroimaging

Methods & Models for fMRI Data Analysis

Objective
1. Consolidation of theoretical knowledge (obtained in the following courses: 'Methods & models for fMRI data analysis', 'Translational Neuroimaging', 'Computational Psychiatry') in the setting of concrete research questions.

Abstract
This seminar teaches problem solving skills for computational neuroimaging, based on analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g. mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.

Content
This seminar teaches problem solving skills for computational neuroimaging, based on analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g. mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.

Prerequisites / notice
The participants are expected to have successfully completed at least one of the following courses:
- Methods & models for fMRI data analysis
- Translational Neuroimaging
- Computational Psychiatry

Competencies
- Subject-specific Competencies:
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered
- Method-specific Competencies:
  - Analytical Competencies: assessed
  - Decision-making: fostered
  - Problem-solving: assessed
- Social Competencies:
  - Communication: fostered
- Personal Competencies:
  - Creative Thinking: fostered
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered

227-0969-00L Methods & Models for fMRI Data Analysis

Objective
To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), including preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM). A Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

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Competencies
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  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered
- Method-specific Competencies:
  - Analytical Competencies: assessed
  - Decision-making: fostered
  - Problem-solving: assessed
- Social Competencies:
  - Communication: fostered
- Personal Competencies:
  - Creative Thinking: fostered
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered

402-0674-00L Physics in Medical Research: From Atoms to Cells

Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies. X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense proton beams and laser pulses are used to create localized hot spots within the human body. These hot spots are used to induce localized cancer cell destruction. The combination of highly intense X rays and laser pulses is used to create localized hot spots within the human body. These hot spots are used to induce localized cancer cell destruction.

Objective
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocye behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanoscale's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

227-2037-00L Physical Modelling and Simulation

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.
Content

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

★★★ Major in Bioengineering
★★★ Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0965-00L</td>
<td>Micro and Nano-Tomography of Biological Tissues</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Stampanoni, F. Marone Welford</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.</td>
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<tr>
<td>Objective</td>
<td>Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications</td>
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<tr>
<td>Content</td>
<td>Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.</td>
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<tr>
<td>Lecture notes</td>
<td>The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.</td>
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<tr>
<td>Literature</td>
<td>The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.</td>
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<tr>
<td>Available online</td>
<td>All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.</td>
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</tbody>
</table>

376-1103-00L | Frontiers in Nanotechnology | W | 4 credits | 4V | V. Vogel, further lecturers |
| Abstract   | Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontsiers. |      |      |       |                            |
| Objective  | Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nanochemistry, nano-mechanics and other properties within mammade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies. |      |      |       |                            |
| Content    | The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries. |      |      |       |                            |
| Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontsiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations. |      |      |       |                            |
| Lecture notes | All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics. |      |      |       |                            |
| Literature | The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments. |      |      |       |                            |
| Available online | All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics. |      |      |       |                            |

376-1714-00L | Biocompatible Materials | W | 4 credits | 3V | K. Manciura, M. Rottmar, M. Zenobi-Wong |
| Abstract   | Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced. |      |      |       |                            |
| Objective  | The course covers the following topics: 1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials. 2. The concept of biocompatibility. 3. Introduction into methodology used in biomaterials research and application. 4. Introduction to different material classes in use for medical applications. |      |      |       |                            |
| Content    | Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontsiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations. |      |      |       |                            |
| Handouts are deposited online (moodle). | Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontsiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations. Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontsiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations. |      |      |       |                            |
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available.

Biomedical Engineering

Objective

Lecturers

Handouts and references therein.

636-0108-00L

Biological Engineering and Biotechnology

W 4 credits

3V

M. Fussenegger

Abstract

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content


Lecture notes

Handout during the course.

Practical Work

Number

Title

Type

ECTS

Hours

Lecturers

465-0800-00L

Practical Work

O

4 credits

external organisers

Abstract

The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

Objective

The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

Electives

376-1622-00L Practical Methods in Tissue Engineering (offered in the Autumn Semester) and 376-1624-00L Practical Methods in Biofabrication (offered in the Spring Semester) are mutually exclusive to be eligible for credits.

Number

Title

Type

ECTS

Hours

Lecturers

151-0604-00L

Microbotics

W 4 credits

3G

B. Nelson

Abstract

Microbotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective

The objective of this course is to expose students to the fundamental aspects of the emerging field of microbotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content

- Main topics of the course include:
  - Scaling laws at micro/nano scales
  - Electrostatics
  - Electromagnetism
  - Low Reynolds number flows
  - Observation tools
  - Materials and fabrication methods
  - Applications of biomedical microbots

Lecture notes

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice

The lecture will be taught in English.

227-0386-00L

Biomedical Engineering

W 4 credits

3G

J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content

- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals. Basic concepts of tissue engineering and organ printing.
- Biomaternal and their medical applications.
- Function of the heart and the circulatory system. Transport and exchange of substances in the human body, compartment modeling. The respiratory system.
- Biomaging: Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.
Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, concepts and theories fostered in physics in medical research: from atoms to cells. The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

- Script with more than 600 pages with many illustrations will be distributed free of charge.

Adaptability and flexibility fostered

---

**Abstract**
The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

**Objective**
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

**Content**
Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere / evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

**Lecture notes**
Script with more than 600 pages with many illustrations will be distributed free of charge.

3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

**Prerequisites / notice**
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

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**327-1101-00L**
**Biomineralization**

<table>
<thead>
<tr>
<th>Competency</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Fostered</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>Fostered</td>
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<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Fostered</td>
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<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
<td>Fostered</td>
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<td>assessed</td>
<td>fostered</td>
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<td>assessed</td>
<td>fostered</td>
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</table>

**376-1622-00L**
**Practical Methods in Tissue Engineering**

<table>
<thead>
<tr>
<th>Competency</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooperation and Teamwork</td>
<td>Fostered</td>
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<td>Customer Orientation</td>
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<td></td>
<td></td>
<td>Leadership and Responsibility</td>
<td>Fostered</td>
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<tr>
<td></td>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>Fostered</td>
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</table>

**402-0674-00L**
**Physics in Medical Research: From Atoms to Cells**

<table>
<thead>
<tr>
<th>Competency</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>Communication</td>
</tr>
</tbody>
</table>

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**Abstract**
The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

**Objective**
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

**Prerequisites / notice**
A laptop is needed with the below Systems Requirements:
- Memory: 16 GB
- Processor: 3rd gen i7
- DirectX® 11.0 compliant AMD Radeon® or NVIDIA® GeForce® card with 2 GB RAM
- Storage: 15 GB

Mac computer can be used by pre-installing Windows through bootcamp (older Macs) or Parallels Desktop (14d trial license, 35 CHF license purchasable in the IT shop of ETH).
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure’s shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams such as micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s anisotropies of biopsies.

Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.


Content

Lecture topics:

1. Introduction

    Sources of bioelectronic signals
    2. Membrane and Transport
    3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

14. Measuring biochemical signals

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics.
In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation

- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

465-0970-00L Image Guided Medical Interventions W 6 credits 2V+1U G. Fattori

Abstract
Computer assistance and robotics have entered many fields of interventional medicine, shaping the way high-precision procedures are performed today. In this lecture series, we will present the methods and technologies used in image-guided radiotherapy, from the use of medical images to model the patient's anatomy to intraoperative navigation and registration.

Objective
Upon completion of the course, students are able to explain the methods and technologies for image guidance and stereotactic radiotherapy. In particular, they are able to design the calibration of in-room imaging solutions and other navigation systems to verify and correct patient position in high-precision radiotherapy. In addition, they are familiar with common tools used in medical image processing research.

Content
Basics of imaging and image processing for IGRT:
- 3D/4D imaging
- Segmentation (thresholding, region growing and similar)
- Filtering (morphological filters and similar fundamentals)
- Modelling and rendering of volumes and surfaces
- Image registration
- Conventions for position and orientation representation

Technologies and methods for localisation and navigation:
- Reference systems mapping
- Kinematic of a robotic treatment couch
- Optical tracking systems, calibration and use
- Registration of points and surfaces
- In-room imaging and geometry calibration of X-ray systems
- 2D/3D and 3D/3D registration
- Organ motion

Technologies and methods for on-line treatment verification
- In-room imaging for verification of proton therapy treatment

If you like playing with medical imaging and computer vision tools, you could be interested in this course.

➡️ Major in Bioelectronics
### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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</table>
| **Content**     | Main topics of the course include:  
- Scaling laws at micro/nano scales  
- Electrostatics  
- Electromagnetism  
- Low Reynolds number flows  
- Observation tools  
- Materials and fabrication methods  
- Applications of biomedical microrobots |
| **Lecture notes** | The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically. |
| **Prerequisites / notice** | The lecture will be taught in English. |
| 227-0386-00L    | Biomedical Engineering   | W    | 4    | 3G        | J. Vörös, S. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong |
| **Abstract**    | Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view. |
| **Objective**   | Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined. |
| **Content**     | History of BME and the role of biomedical engineers. Ethical issues related to BME.  
Biomedical sensors both wearable and also biochemical sensors.  
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.  
Bioinformatics: genomic and proteomic tools, databases and basic calculations.  
Equations describing basic reactions and enzyme kinetics.  
Medical optics: Optical components and systems used in hospitals.  
Basic concepts of tissue engineering and organ printing.  
Biomaterials and their medical applications.  
Function of the heart and the circulatory system.  
Transport and exchange of substances in the human body, compartment modeling.  
The respiratory system.  
Bioimaging.  
Orthopedic biomechanics.  
Lectures (2h), discussion of practical exercises (1h) and homework exercises. |
| **Lecture notes** | Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino  
AND  
moodle page of the course |
| **Prerequisites / notice** | No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.). |
| 227-1037-00L    | Introduction to Neuroinformatics | W    | 6    | 2V+1U+1A | V. Mante, B. Grewe, G. Indiveri, M. Payvand |
| **Compencies**  | Subject-specific Competencies  
- Concepts and Theories  
- Techniques and Technologies |
| **Method-specific Competencies** |  
- Analytical Competencies  
- Decision-making  
- Media and Digital Technologies  
- Problem-solving  
- Project Management |
| **Social Competencies** |  
- Communication  
- Cooperation and Teamwork  
- Customer Orientation  
- Leadership and Responsibility  
- Self-presentation and Social Influence  
- Sensitivity to Diversity |
| **Personal Competencies** |  
- Adaptability and Flexibility  
- Critical Thinking  
- Integrity and Work Ethics  
- Self-awareness and Self-reflection  
- Self-direction and Self-management |

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**Autumn Semester 2024**
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocolures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

<table>
<thead>
<tr>
<th>376-1714-00L</th>
<th>Biocompatible Materials</th>
<th>W</th>
<th>4 credits</th>
<th>3V</th>
<th>K. Maniura, M. Rottmar, M. Zenobi-Wong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The course covers the following topics: 1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials. 2. The concept of biocompatibility. 3. Introduction into methodology used in biomaterials research and application. 4. Introduction to different material classes in use for medical applications.</td>
<td></td>
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<tr>
<td>Content</td>
<td>Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.</td>
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<table>
<thead>
<tr>
<th>227-0393-10L</th>
<th>Bioelectronics and Biosensors</th>
<th>W</th>
<th>6 credits</th>
<th>2V+2U</th>
<th>J. Vörös, M. F. Yanik</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectric signals and the basic concepts to record optogenetically modified organisms are introduced.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>During this course the students will: - learn the basic concepts in bioelectronics including the sources of bioelectric signals and the methods to measure them - be able to solve typical problems in bioelectronics - learn about the remaining challenges in this field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>A detailed script is provided to each lecture including the exercises and their solutions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)</td>
<td></td>
<td></td>
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</tbody>
</table>
Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

## ➤➤➤ Practical Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>465-0800-00L</td>
<td>Practical Work</td>
<td>O</td>
<td>4</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

Abstract
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution. The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

## ➤➤➤ Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Deibrück, G. Indiveri, S.-C. Liu, M. Payvand</td>
</tr>
</tbody>
</table>

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
- Understanding the characteristics of neuromorphic circuit elements.

Content
- Neuronic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice
- Particular: The course is highly recommended for those who intend to take the spring semester course 'Neuromorphic Engineering II', that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

- Prerequisites: Background in basics of semiconductor physics helpful, but not required.

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<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>J. Smajic</td>
</tr>
</tbody>
</table>

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
- Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or choose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
<th>Lecturer</th>
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<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>4</td>
<td>V. Vogel, further lecturers</td>
</tr>
<tr>
<td>402-0674-00L</td>
<td>Physics in Medical Research: From Atoms to Cells</td>
<td>6</td>
<td>B. K. R. Müller</td>
</tr>
<tr>
<td>529-0837-01L</td>
<td>Biomicrofluidic Engineering</td>
<td>6</td>
<td>A. de Mello</td>
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**Abstract**

**Objective**

**Content**

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<td>Biomicrofluidic Engineering</td>
<td>6</td>
<td>A. de Mello</td>
</tr>
</tbody>
</table>

**Abstract**

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies that will be covered will start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epilithal growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultraviolet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-ul, environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.

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Content

Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, ‘soft’ lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small Scale Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

Lecture notes

Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

Literature

There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed

ECTS
66 credits
4 credits
3V

Biological Engineering and Biotechnology
W 4 credits 3V M. Fussenegger

Abstract

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content

1. Insight Into The Mammalian Cell Cycle. Cycling, The Balance Between Proliferation and Cancer - Implications For Biopharmaceutical Manufacturing
2. The Licence To Kill. Apoptosis Regulatory Networks - Engineering of Survival Pathways To Increase Robustness of Production Cell Lines
5. From Target To Market. An Antibody's Journey From Cell Culture to The Clinics
9. IP Culture to The Clinics
10. Biopharmaceutical Manufacturing. Introduction to Process Development
11. Biopharmaceutical Manufacturing II. Up-stream Development
12. Biopharmaceutical Manufacturing III. Downstream Development
13. Biopharmaceutical Manufacturing IV. Pharma Development

Lecture notes

Handout during the course.

Major in Neuroinformatics

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6</td>
<td>2V+1U+1A</td>
<td>V. Mante, B. Grewe, G. Indiveri, M. Payvand</td>
</tr>
</tbody>
</table>

Abstract

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.
Objective
Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

227-0393-10L Bioelectronics and Biosensors W 6 credits 2V+2U J. Vörös, M. F. Yanik

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectric signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectric signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content
Lecture topics:
1. Introduction
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley
Measuring bioelectric signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics
10. Functional electric stimulation
11. In vivo electrophysiology
12. Measuring mechanical signals with bioelectronics
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy
14. Measuring biochemical signals

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Social Competencies
- fostered
- fostered
- fostered
- fostered
- fostered
- fostered
- fostered
- fostered

Personal Competencies
- fostered
- fostered
- fostered
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- fostered
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- fostered

227-0421-00L Learning in Deep Artificial and Biological Neuronal Networks W 4 credits 3G B. Grewe

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1708 of 2667
Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:

- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Content

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world.

However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al., 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience.

The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

### Practical Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>465-0800-00L</td>
<td>Practical Work</td>
<td>O</td>
<td>4 credits</td>
<td>external organisers</td>
<td></td>
</tr>
</tbody>
</table>

#### Abstract

Practical Work

The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

#### Objective

The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neurorhmic Engineering I</td>
<td>W</td>
<td>6 credits</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu, M. Payvand</td>
</tr>
</tbody>
</table>

#### Abstract

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

#### Objective

Understanding of the characteristics of neuromorphic circuit elements.

#### Content

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, digital circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

#### Literature

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

#### Prerequisites / notice

- Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.
- The participation in the course is subject to the following conditions:

  1. The number of participants is limited to 120 students (MSc and PhDs).
  2. Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

---

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1709 of 2667
376-1791-00L Introductory Course in Neuroscience I (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: SPV0Y005

Abstract
The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.

Objective
The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.

Content
1) Human Neuroanatomy I&II
2) Comparative Neuroanatomy
3) Building a central nervous system I&II
4) Synapses I&II
5) Glia and more
6) Excitability
7) Circuits underlying Emotion
8) Visual System
9) Auditory & Vestibular System
10) Somatosensory and Motor Systems
11) Learning in artificial and biological neural networks

Prerequisites / notice
For doctoral students of the Neuroscience Center Zurich (ZNZ).

376-1622-00L Practical Methods in Tissue Engineering (offered in the Autumn Semester) and 376-1624-00L Practical Methods in Biofabrication (offered in the Spring Semester) are mutually exclusive to be eligible for credits.

227-2037-00L Physical Modelling and Simulation
W 6 credits 4G J. Smajic

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

227-1051-00L Systems Neuroscience (University of Zurich)
W 6 credits 2V+1U D. Kiper

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.
Practical Methods in Tissue Engineering

The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

Objective
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Prerequisites / notice
A laptop is needed with the below Systems Requirements:
- Memory: 16 GB
- Processor: 3rd gen i7
- DirectX® 11.0 compliant AMD Radeon/NVIDIA® GeForce® card with 2 GB RAM
- Storage: 15 GB

Mac computer can be used by pre-installing Windows through bootcamp (older Macs) or Parallels Desktop (14d trial license, 35 CHF license purchasable in the IT shop of ETH).


Elective

Practical Work

The practical work is designed to train the students in the solution of a specific problem and provides insights into the development of project contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Handouts and references therin.

Biominerization

The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biominerallization.

The course aims to introduce the basic concepts of biominerallization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.
Biominalization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biominalization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominalizers and their functions
3. Chemical control of biominalization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

Script with more than 600 pages with many illustrations will be distributed free of charge.

Literature
3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

Abstract
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Objective
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

<table>
<thead>
<tr>
<th>227-0393-10L</th>
<th>Bioelectronics and Biosensors</th>
<th>W 6 credits</th>
<th>2V+2U</th>
<th>J. Vörös, M. F. Yanik</th>
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<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectric signals and the basic concepts to record optogenetically modified organisms are introduced.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Lecture topics:</td>
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<tr>
<td></td>
<td>1. Introduction</td>
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<td>2. Membrane and Transport</td>
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<td>3-4. Action potential and Hodgkin-Huxley</td>
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<td></td>
<td>Measuring bioelectric signals</td>
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<td>5. Detection and Noise</td>
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<td></td>
<td>6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes</td>
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<td>7. Measuring potentials in solution and core conductance model</td>
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<td>8. Measuring electronic signals with wearable electronics, ECG, EEG</td>
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<td>9. Measuring mechanical signals with bioelectronics</td>
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<td></td>
<td>In vivo stimulation and recording</td>
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<td>10. Functional electric stimulation</td>
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<td>11. In vivo electrophysiology</td>
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<td></td>
<td>Optical recording and control of neurons (optogenetics)</td>
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<td></td>
<td>12. Measuring neurons optically, fundamentals of optical microscopy</td>
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<td></td>
<td>13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy</td>
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<td></td>
<td>14. Measuring biochemical signals</td>
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**Prerequisites / notice**
In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants, products, etc.).
Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

Content
Building upon new technologies to engineer and functionalize well-defined nanostructured materials, a plethora of exciting discoveries were made and found their way in our daily life. These customized nanomaterials provides extraordinary properties and make them attractive for many innovative applications. Exactly these new properties may have the potential to be responsible for unforeseen side effects, which hamper a straightforward translation into new products. Therefore, the safety research provide the evidence for a responsible and sustainable use of nanomaterials.

The lecture will focus on basic principles of nanotoxicology, provide the understanding of the potential side effects of nanomaterial in a context-specific way addressing the main exposure routes such as inhalation, ingestion, topical applications and intravenous injections as well as it will provide impulses for safer material designs.

Structure of the planned lecture (2 x 45 min)
1. Introduction: the principles of nanotoxicology
2. Lung- particles interactions: two disease scenarios and their molecular mechanism
3. GI – particles interactions: intendent and unintendent particle exposure via food
4. Skin – particles interactions: body care products and their influence on skin physiology
5. intravenous injection: colloidal stability, protein corona and cellular effects
6. Micro- / Nanoplastics and development of a safety research plan
7. End of semester exam

Lecture notes
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

Prerequisites / notice
Course “Introduction to Toxicology”
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected

### Practical Work

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### Electives

#### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>327-1101-00L</td>
<td>Biomineralization</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>K.-H. Ernst</td>
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</table>

The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

Content
Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM) / types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolarians and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere / evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
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6. BM in matrices: bone and nacre
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8. Invertebrate teeth
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11. Iron storage and mineralization

Lecture notes
Script with more than 600 pages with many illustrations will be distributed free of charge.

Literature
3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

Prerequisites / notice
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
<th>Data: 02.07.2024 12:39</th>
<th>Autumn Semester 2024</th>
<th>Page 1716 of 2667</th>
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<tbody>
<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>W 4V</td>
<td>W 4V</td>
<td>W 4V</td>
<td>V. Vogel, further lecturers</td>
</tr>
</tbody>
</table>
| Abstract     | Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers. Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within mammade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies. The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries. Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

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<th>Autumn Semester 2024</th>
<th>Page 1716 of 2667</th>
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<tr>
<td>402-0674-00L</td>
<td>Physics in Medical Research: From Atoms to Cells</td>
<td>W 6V+1U</td>
<td>W 6V</td>
<td>W 6V</td>
<td>B. K. R. Müller</td>
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<tr>
<td>Abstract</td>
<td>Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.</td>
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The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

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<td>Subject-specific Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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Further references will be provided in the course.

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<tr>
<td>Further references will be provided in the course.</td>
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<table>
<thead>
<tr>
<th>Objective</th>
<th>Drug Delivery and Drug Targeting</th>
<th>W 2 credits 1.5V J.-C. Leroux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.</td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.</td>
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<tr>
<td>Lecture notes</td>
<td>Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.</td>
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<tr>
<td>Further references will be provided in the course.</td>
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<table>
<thead>
<tr>
<th>Objective</th>
<th>Molecular and Structural Biology I: Protein Structure and Function</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.</td>
</tr>
<tr>
<td>Objective</td>
<td>Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.</td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Scripts on the individual topics can be found under <a href="http://www.mol.biol.ethz.ch/teaching">http://www.mol.biol.ethz.ch/teaching</a>.</td>
</tr>
</tbody>
</table>
Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Hours</th>
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<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4</td>
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<td></td>
<td>Objective</td>
<td>M. Fussenegger</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
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<td></td>
<td>Current topics: References will be given during the lectures.</td>
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<tr>
<th>Course Code</th>
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<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
<td>W</td>
<td>6</td>
<td>G</td>
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<tr>
<td></td>
<td>Objective</td>
<td>J. Smajic</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.</td>
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<tr>
<td></td>
<td>Content</td>
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<th>Course Code</th>
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<tr>
<td></td>
<td>Lecture notes</td>
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<td>Handout during the course.</td>
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<tr>
<td></td>
<td>MAS in Medical Physics - Key for Type</td>
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<td>Eligible for credits</td>
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| Key for Hours | | |
|---------------|---------------|
| V             | lecture       |       | P     | practical/laboratory course |
| G             | lecture with exercise |       | A     | independent project |
| U             | exercise      |       | D     | diploma thesis |
| S             | seminar       |       | R     | revision course / private study |
| K             | colloquium    |       |       |       |

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<tr>
<th>ECTS</th>
<th>European Credit Transfer and Accumulation System</th>
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<td>0</td>
<td>Special students and auditors need special permission from the lecturers.</td>
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</tbody>
</table>
# MAS in Future Transport Systems

Four-semester, part-time MAS programme.


## Major in Systemic Aspects of Future Transport

The Major in "Systemic Aspects of Future Transport" takes place every 1.5 years according to the program website.

**Course duration: Six months part time**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>166-0100-00L</td>
<td>Transport Systems: Dynamics and Future Developments</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
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</table>

**Abstract**
Interrelationships and dynamic change and the impact of these on mobility and transportation are being investigated in this module. The module addresses desirable future development of urban transport systems in Switzerland by covering and critically examining authentic, existing transport scenarios (e.g. ARE) in an exercise setting which deploys backcasting.

**Objective**
- understand the complexity of the transport system status quo as a whole, and are able to describe it qualitatively and create an operational and/or working context (K1).
- understand the dynamics of transport systems and future transport scenarios over time, and can infer objectives from the latter (K2).
- understand the dynamics between spacial quality and mobility behavior and can evaluate how measures to promote active mobility can contribute to a more sustainable transport system (K3).
- understand how digitalisation drives new mobility services (mobility as a service), and are able to qualitatively estimate the changes these bring to transport systems as a whole (K4).
- are able to pinpoint the challenges and potential of the transition to autonomous transport forms (K5).

**Content**
- Deepen understanding of complex transport systems and their dynamics past – status quo – future
- Consolidate a foundation in the dynamics of transport systems: elements and their interrelationships
- Overview and selection of methods/approaches for the development and analysis of scenarios
- Future perspectives (ARE), target scenarios
- Transformation and change in systems
- Transport policy and the potential of regulation
- Excursion: "Infrastructure to support active mobility: Bike capital Bern"

**Methods selected**
- System analysis, scenario analysis, foresight, indicators for sustainable mobility, Case studies, reading and discussion of thesis papers and scientific publications

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<tr>
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<tbody>
<tr>
<td>166-0101-00L</td>
<td>Development and Assessment of Transport Scenarios</td>
<td>O</td>
<td>3 credits</td>
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</table>

**Abstract**
This module familiarises participants with current methods of developing and evaluating transport scenarios. These include analysis of the interrelationship of space and traffic; traffic modelling methods; and evaluation according to economic and planning criteria.

**Objective**
- are familiar with suitable methods for developing transport scenarios and how to analyse and evaluate them. In particular, they know how to address the challenges of evaluating future forms of transport;
- are able to select a suitable method and determine an evaluation concept with relation to a specific problem.

**Content**
- Methodological foundations of traffic modelling (44-level model, activity-based model, agent-based simulation)
- Design and evaluation of transport scenarios using MATSim (traffic simulation) with a focus on transport with autonomous vehicles
- Interrelationship of space and traffic (accessibility measurement, settlement density and mixed usage) and what to consider in designing and evaluating transport scenarios
- Approaches to evaluation of traffic scenarios (cost-benefit analyses and their foundations, methodological limits), analysis of effects taking into account user group and space type
- Ecobalancing with Life Cycle Assessment (LCA) in addressing passenger and goods transport issues
- Development of case studies on shared transport and mobility with an activity- and agent-based transport simulation model

**Methods**
- Aggregated and activity-based transport demand models
- Agent-based simulation
- Cost-benefit analysis
- Accessibility analysis

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<tr>
<td>166-0102-00L</td>
<td>Foundations for the Design of Transport System Innovation and Change Processes</td>
<td>O</td>
<td>3 credits</td>
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</table>

**Abstract**

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1719 of 2667
Objective

Participants are able...
- to understand the economic and social-scientific fundamentals of innovation and change processes in the area of transportation;
- to analyse the foundations, opportunities and challenges of disruption in mobility systems;
- to set this concepts and frameworks in context to pathways towards more sustainable mobility;
- and to set these concepts and frameworks constructively in context to their own work practice.

Content

In this module, innovation, change and transitions in transportation systems on different levels are discussed from different complementary perspectives. Both economic and social science approaches to the analysis, anticipation and governance of innovation processes are presented, discussed and applied to current issues. Topics are:
- Respective theories and methods;
- Innovation as an economic discovery process, measuring innovation;
- Emerging trends as new opportunities for innovation;
- Innovation today in the transportation/mobility system: theoretical basis and concrete examples;
- Transition of socio-technical systems, co-evolution of technical and societal dynamics;
- The relevance of social acceptance and ethical aspects for innovations in mobility.

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

166-0103-00L

System Aspects of Air and Shipping Traffic

Abstract
Air and shipping traffic cover a substantial part of human mobility, air traffic in passenger as well as freight transport, shipping mainly in freight transport. Students gain an overview, limit modes of mobility and learn to classify air and shipping traffic in the overall system of mobility.

Objective

Participants
- know the fundamental differences between air, shipping traffic compared to motorized individual transport and public transport.
- are able to deduce differences between air and shipping traffic.
- know the possibilities and limits as well as pros and cons of different valuation methods used for air and shipping transport.
- develop ideas for suitable indicators to evaluate scenarios in air and shipping traffic.

Content
- Key figures, development and trends in air and shipping traffic.
- Potentials for holistic improvement in air and shipping traffic.
- Life Cycle Assessment (LCA) for questions in air and shipping traffic.
- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Berechnung und Interpretation von Kennzahlen.

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS/CAS at the beginning of the term

166-0190-00L

CAS Thesis on System Aspects

Abstract
The participants deal with a current problem from the topics of CAS System Aspects.

Objective

Participants
- able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- can identify and arrange relevant stakeholders, frame solutions and develop ideas for the implementation and deployment of solutions.
- can design, develop and implement concepts and frameworks for the analysis, development and implementation of solutions.
- can present, discuss and apply these concepts and frameworks in context of current issues.
- can transfer ideas of their own work practice and the results of their academic work to the context of current issues.

Content

In the CAS-Arbeit zeigen die Studierenden, dass sie in der Lage sind, eine fundierte aufbereitete Auseinandersetzung mit technischen und nicht-technischen Entwicklungen im Mobilitätsystem und ihren möglichen Auswirkungen auf das Schweizer Verkehrssystem oder auf Teilbereiche desselben anzufertigen.

Die Teilnehmenden setzen sich dabei aktiv mit aktuellen und/oder zukünftig erwarteten Entwicklungen im Mobilitätssektor auseinander, übersetzen mögliche Entwicklungen in verkehrliche Parameter (=Zukunft der Mobilität); greifen auf Lerninhalte des Studiums zurück; entwickeln ausgewählte Themen selbständig weiter (bzw. im Rahmen einer Arbeitsgruppe) und setzen sich mit der Relevanz für die Praxis auseinander (Relevanz für Stakeholdergruppen wie z.B. politische Entscheidungsträger, Verkehrsunternehmen, Industrie, Umweltverbände, Energieversorger sowie auch andere gesellschaftliche Gruppen, z.B. für Menschen im Rentenalter).

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

Major in Technology Potential

The Major in "Major in Technology Potential" takes place every 1.5 years according to the program website.

Course duration: Six months part time

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>166-0200-00L</td>
<td>Technology Potential: Powertrain, Systems and Energy Carriers</td>
<td>O</td>
<td>3.5 credits</td>
<td>3G</td>
<td>C. Onder</td>
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Abstract
The module provides a foundation in the current situation and short- and middle-term development directions of powertrain and automotive engineering in the context of passenger & goods transport. Corresponding energy sources and resulting consequences for the energy system are addressed. Participants will be enabled to identify potentials of these technologies and apply them to concrete problems.

Objective
Familiarity with conventional and alternative powertrain and automotive systems for future sustainable mobility, and the ability to identify and deploy their potential to address concrete problems.

Content
- Drive component efficiency rates and core fields
- Drive and non-drive energy flow / Vehicle "driving resistance"
- Energy chains (operating power only) and CO2 emissions to primary energy

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

166-0201-00L | Potential of Spatial Information- and Communication Technologies | O    | 3 credits | 3G    | M. Raubal  |
The digital revolution, spatial information and communication systems in particular, have a significant influence on the development of new transport systems. Participants acquire an in-depth understanding of the functionality and application potential of spatial information systems and services and of communication technologies for deployment in future transport systems and applications.

**Objective**
Familiarity with information and communication technologies (ICT) and spatial information technologies, and the ability to identify and utilise their potential to address concrete problems.

**Content**
- Functionality and application of geographic information systems (GIS) to represent and analyse transport systems (acquire, model, analyse and visualise geodata)
- Deployment potentials of GIS and ICT for efficient transport solutions (tangible, non-tangible)
- Functionality and application of mobile spatial information technologies in future transport systems
- Methods of spatiotemporal analysis and geodata analysis
- Technical aspects of information and communication technologies (ICT)
- Modelling, simulation and assessment of traffic behaviour
- Basics of autonomous driving
- Legal aspects of geodata
- Applications: Traffic behaviour in Switzerland; location based services for energy-efficient behaviour; GIS for the Zurich traffic system (multimodal)

**Lecture notes**
Distributed at start of module

**Literature**
Distributed at start of module

**Prerequisites / notice**
Announced to students of the of the MAS / CAS at the beginning of the term.

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**166-0202-00L Integrated Assessment of Technologies and Transport Systems**

**Abstract**
The module provides a solid introduction to integrated technology assessment with regard to economic, ecological and social criteria. It introduces life cycle assessment (LCA), cost assessment, risk assessment and multi-criteria decision analysis. It also presents scenario analyses based upon energy-economic models which explicitly represent transport and energy-supply technologies.

**Objective**
An overview of suitable methods for analysing and evaluating technical systems (transport systems) and the ability to choose among them to address concrete problems.

**Content**
1. Introduction to and overview of integrated assessment
   - Current status of transport in Switzerland and internationally
   - Scope and goals of integrated assessment
   - Sustainability: concept and practical implementation via criteria and indicators
   - Overview of concepts and implementation methods
2. Selected methods for assessing transport technologies and their application to current and future options
   - Ecobalance / life cycle assessment (LCA)
   - Location-specific assessment of health hazards and environmental pollution
   - Risk analysis
   - Internal cost assessment
   - External cost assessment
3. Integrated assessment of transport technologies
   - Overall costs (internal and external)
   - Multi-criteria analysis
4. Analysis of transport scenarios
   - Scenarios, influencing factors, policy and sustainability
   - Approaches to scenario modelling
   - Global mobility scenarios: examples
   - Transport scenarios for Switzerland using energy system models

**Lecture notes**
Distributed at start of module

**Literature**
Distributed at start of module

**Prerequisites / notice**
Announced to students of the of the MAS / CAS at the beginning of the term.

---

**166-0203-00L Energy Carrier for the Mobility of the Future**

**Abstract**
The module includes the supply of the road mobility of the future with renewable energy. The generation, transport, processing, transfer of energy to the vehicles (refueling, charging) and the energetic evaluation are presented. Electricity, hydrogen, biogenic and synthetic fuels are considered.

**Objective**
The aim of the module is a detailed energetic and technical understanding of the supply of road vehicles with renewable energy. Graduates know the primary energy production as well as the end energy processing of the different energy carrier concepts. In addition, they know the legal CO2 requirements for vehicle registration and are able to qualitatively assess the impact on the Swiss energy system.

**Content**
- The energy system of the future; biogenic and electric renewable primary energy
- End energy processing
- Transfer from the energy system to mobility and influences on the overall energy system

**Lecture notes**
Distributed at start of module

**Literature**
Distributed at start of module

**Prerequisites / notice**
Announced to students of the of the MAS / CAS at the beginning of the term.

---

**166-0290-00L CAS Thesis on Technology Potentials**

**Abstract**
The participants, in heterogeneous teams, deal with a current problem from the topics of the CAS Technology Potentials.

**Objective**
- Deal with a specific problem from the CAS Technology Potentials subject area.
- Be able to work interdisciplinarily and across sectors, where appropriate together with relevant other parties.
- Communicate the results appropriately.

**Lecture notes**
Distributed at start of module

**Literature**
Distributed at start of module

**Prerequisites / notice**
Announced to students of the of the MAS / CAS at the beginning of the term.

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**Major in New Business Models**
The "CAS in Future Transport Systems: New Business Models" takes place every 1.5 years according to the program website.

Course duration: Six months part time


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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>166-0300-00L</td>
<td>Framework Conditions and Transport Behaviour</td>
<td>O</td>
<td>3.5</td>
<td>3G</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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</tbody>
</table>

Abstract

This module addresses the demand for new business models for future transport systems. Why and in what way do people wish to be mobile? What are the economic, social and legal framework conditions, and how will these develop? What approaches leading to new value propositions will follow?

Objective

- can tell the difference between drivers of mobility which cannot really change and those which can change;
- are able to identify the effects of path dependence on transport systems and future transport systems;
- are familiar with the socio-psychological factors involved in transport vehicle acquisition and transport behaviour, and can apply them in ideas for new business models;
- are able to judge the significance of travel time, driving time and fixed costs and use this knowledge to identify new business models;
- are able to design incentives which will trigger maximum changes in behaviour and/or facilitate cooperative behaviour;
- are able to embed electric mobility conceptually such that its potential is realised and the associated risks are minimised;
- are familiar with the framework conditions and efficient drivers required to replace overland transport with air transport;
- are able to assemble combinations of political and market instruments on the basis of their efficiency profiles and side-effects in order to realise efficiency potentials and changes in behaviour;
- are able to design policy and market measures in such a way that they minimise rebound effects (including those in connection with automatic and fully autonomous vehicles);
- are able to recognise the properties of automatic and fully autonomous vehicles which are particularly suitable for new business models.

Content

- Why are people mobile? What resources (time, money, space) do they invest in mobility?
- What are the various qualities of transport services (comfort/stress, risk/safety, plannability, multifunctionality)?
- What are the various resource and quality profiles of current transport services, and what mutual dependencies are there?
- What current mobility demands are unsated? Why are they unsated? What future key technologies might change this?
- What current forms of mobility might be substituted by other transport services? If they were substituted, how would the necessary resources and transport service qualities change?

Methods

- Group work (groups of four and groups of two)
- Creative methods for generating value propositions
- Tasks in preparation for the fourth course day: design, implementation and analysis of a small survey of potential target clients regarding a not-yet-existing business model

Case studies

- Reciprocal presentation of personally compiled case studies

Lecture notes

Distributed at start of module.

Literature

Distributed at start of module.

Prerequisites / notice

Announced to students of the of the MAS | CAS at the beginning of the term.

166-0301-00L | New Business Models for Future Transport Systems | O    | 3 credits | 2G |

Does not take place this semester.

Abstract

This module addresses the implementation of (digital) strategies and innovative business models of the future and elucidates the drivers, inhibitors and challenges of business model innovation. Using suitable methods and procedures, participants in the module develop, evaluate and refine prototypes of sustainable future business models.

Objective

- are able to understand and explain the core issues, concepts and strategies of business model innovation;
- are able to describe the relevance and the process of business model development;
- are able to translate a personally developed business case into a sustainable business model;
- are able to apply suitable design strategies to optimise a personally developed business model;
- are able to appropriately embed new business models into a corporate or business segment strategy;
- are able to assess the strengths, weaknesses, opportunities and risks of a business model;
- are able to convincingly present their own business case / business model in a structured manner to relevant stakeholder groups (investors, board members, clients, partners);
- are able to engage with and develop various points of view to assess business models;
- are able to shape a modelling process for themselves and reflect on it.
Business model innovation:
• Conceptual foundations of business model innovation
• Drivers, inhibitors and challenges of business model innovation
• Business model innovation in established organisations and structures
• Case study and mini cases in the context of transport system / mobility business model innovation

Business modelling (essentials):
• Business model thinking and modelling
• The Business Model Canvas as a conceptual and methodological tool
  o Customer benefits / value propositions
  o Demand side
  o Supply side
• Business model patterns

Business modelling (application)
• Creation of a real business case for business modelling
• Business model prototyping (basis: Business Model Canvas)
• Evaluation and review/re-prototyping of participants’ own business cases / business models

Incorporating new business models into corporate / business segment strategies
• Fit with strategic analysis
• Compliance with corporate or business segment strategy
• Contribution to strategy implementation

Presenting business models convincingly (basics/application)
• Basics of business model presentation
• Development of participants’ own storylines and presentation structure (business value concept)
• Pitching of own business case / business model

Methods
• Blended learning elements to prepare for classroom sessions
• Case studies and examples; group work (4-person and 2-person groups)
• Classroom discussions to introduce relevant concepts and instruments
• Homework for the 4th and 5th NG-2 course days: Develop a structured presentation of a personally developed business case (business model) for delivery to relevant stakeholder groups (investors, board members, clients, partners)

Case studies
• Reciprocal presentations of personally developed business cases

Lecture notes
Distributed at start of module.

Literature
Distributed at start of module.

Prerequisites / notice
Announced to students of the of the MAS | CAS at the beginning of the term.

166-0302-00L Implementing New Strategies and Business Models for Future Transport Systems  O  3 credits  2G

Does not take place this semester.

Abstract
In order to be successful, new strategies / innovative business models have to be implemented in the market as well as in the company itself. This requires proactively managed transition processes. This module deals with such transition processes on three levels: change management theory – best-practice examples – one’s own practice.

Objective
Participants…
• know and understand selected classic and current theories regarding change (management) in systems
• know how to design and initiate participative transition processes
• are familiar with / know how to apply selected tools of change management
• have discussed best-practice cases with responsible managers within the mobility/transportation sector
• have reflected theory and best-practice cases in regard to their own practice
• have developed management options and approaches for their own practice

Content
• Classic and current change management approaches
• Communication in transition processes
• Participation: integration of stakeholders
• Dealing with resistances
• Discussions with guests from practice regarding the management of transition processes related to the implementation of new strategies / business models

Methods
• Selected change management methods and tools

Case studies
• Various good/best practice cases within the mobility sector
• Change cases of students

Lecture notes
Distributed at start of module.

Literature
Distributed at start of module.

Prerequisites / notice
Announced to students of the of the MAS | CAS at the beginning of the term.
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: assessed
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

166-0303-00L Agile and User-Centered Innovation ▼ Does not take place this semester.

Abstract
For companies it is essential to realise products quickly, economically and in a customer-oriented way. In this context approaches to agile and user-centred product development such as Scrum and Design Thinking are increasing in importance. Compared to traditional product development methods, agile methods promise higher quality and customer satisfaction coupled with reduced expenditure.

Objective
Design and realisation of product development projects for future transport systems: Participants are familiar with the methods and procedures of agile and user-centred product development and are able to apply them profitably in their enterprises.

Content
Participants define an innovation theme themselves in groups, and a selection of topics is then drawn from this theme for module group work. The module takes participants through the whole process, from the analysis of target groups and their requirements through project conception and planning to implementation in example form. The course is practical and uses concrete examples. At the end of the module participants will have deployed the methods of agile and user-centred product development to work very practically through a theme they have developed themselves, and will have become familiar with the typical application scenarios, advantages and hurdles associated with these methods.

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the MAS/CAS at the beginning of the term

Competencies

Subject-specific Competencies
- Concepts and Theories: fostered

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Problem-solving: fostered
- Project Management: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered

166-0390-00L CAS Project: New Business Models

Abstract
The participants, in heterogeneous teams, deal with a current problem from the topics of the CAS New Business Models.

Objective
- Deal with a specific problem from the CAS New Business Models subject area.
- Be able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- Communicate the results appropriately.

Lecture notes
Distributed at start of module.

Literature
Distributed at start of module.

Prerequisites / notice
Announced to students of the CAS at the beginning of the term.

Additional Task MAS|CAS

Depending on the need, the "Additional task MAS|CAS" Module takes place every Semester.

Master's Thesis

Number Title Type ECTS Hours Lecturers
166-0490-00L MAS Thesis O 15 credits 27D C. Onder

Note: The previous course title until HS23 "Master's Thesis".

Abstract
Individually and independently, students address a practice-related problem in the area of future transport systems. To do this they deploy, under the supervision of an expert, what they have learned in the MAS programme. They set out the problem, the procedure and the solution in a written report which they present and defend in front of a specialist audience.

Objective
- Ability to draw up solutions in the context of future transport systems.
- Ability to communicate these solutions in a manner suited to a particular target audience.
Content

- Introductory colloquium: Working scientifically and presenting a project idea
- Individual and independent work on a problem selected by the participant
- Interim colloquium: Presentation of the status quo
- Individual supervision by the lecturer
- Compilation of the written thesis and preparation of the presentation
- Examination colloquium: Presentation and defence

Lecture notes

Distributed at start of module

Literature

Distributed at start of module

Prerequisites / notice

Announced to students of the of the MAS at the beginning of the term.

MAS in Future Transport Systems - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
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<tbody>
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<td>Eligible for credits and recommended</td>
<td>Z</td>
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<tr>
<td>W</td>
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<td>Dr</td>
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Key for Hours

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<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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<tbody>
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<td>R</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

ECTS

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
MAS in Spatial Development

Four-semester, part-time MAS programme.

Start of the next course: Autumn Semester 2023

Introduction

Number  Title  Type  ECTS  Hours  Lecturers
135-0001-00L  Introduction: Basics of Spatial Planning  O  3 credits  2G  S. Kissling, A. Rupf, J. Van Wezemael

Abstract  Orientation and preparation for further education in the field of spatial planning and development. Introduction to the Spatial Planning Act and its instruments, assessment of participants' knowledge. Completion through mandatory assessment.

Spatial Development and Planning Practice

Findet 2-jährlich im HS statt.

Number  Title  Type  ECTS  Hours  Lecturers
135-0100-00L  Module 1: Spatial Planning  O  2 credits  1G

Does not take place this semester.

Abstract  Overview of current and future tasks of spatial planning, discussion of formal and informal instruments, and introduction to a methodical way of action-oriented planning. (Tasks, methods and instruments).

135-0101-00L  Module 2: Space as a Complex Situation  O  2 credits  1G

Abstract  Introduction to the nature and pitfalls of complex situations, methods and processes for treatment. Introduction to spatial planning and planning actions in multi-actor networks. (Perceiving, acting and arguing in complex situations).

135-0102-00L  Module 3: Integrated Urban Design  O  2 credits  1G

Does not take place this semester.

Abstract  Inputs for the integrated development of livable urban spaces in connection with central aspects and mechanics of mobility, open spaces, and social spaces. (In the tension field of mobility, open space, and society).

135-0103-00L  Module 4: Functional Regions  O  2 credits  1G

Does not take place this semester.

Abstract  Discussion of the development of large-scale and cross-border spaces. Designing and planning in multi-actor networks, spatial concepts as a basis for cooperation and coordination tasks. (Designing and developing large-scale tasks).

135-0104-00L  Module 5: Shaping Transformation  O  2 credits  1G  further lecturers

Abstract  Exploration of current and future questions of planning law and discussion of the further development of planning instruments and processes. (Law, process, and instruments II).

135-0105-00L  Design Studio  O  5 credits  5G

Does not take place this semester.

Abstract  Module 1-5: Introduction of the task and excursion, integrated location assessment, development of viable action options and interim critique, overall concept and in-depth study, finalization and final critique.

Spatial Development and Process Design

Findet 2-jährlich im FS statt.

Future of Spatial Development

Findet 2-jährlich im HS statt.

Wird zum ersten Mal im Herbstsemester 2024 angeboten.

Master's Thesis

Findet 2-jährlich im FS statt.

Wird zum ersten Mal im Frühjahrsemester 2025 angeboten.

MAS in Spatial Development - Key for Type

O  Compulsory  E-  Recommended, not eligible for credits
W+  Eligible for credits and recommended  Z  Courses outside the curriculum
W  Eligible for credits  Dr  Suitable for doctorate

Key for Hours

V  lecture  P  practical/laboratory course
G  lecture with exercise  A  independent project
U  exercise  D  diploma thesis
S  seminar  R  revision course / private study
K  colloquium

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Technology and Public Policy

Two-semester full-time or four-semester part-time programme.

More information at: https://tpp.ethz.ch/tpp-degrees/mas-tpp.html

➤ Compulsory Modules

➤➤ Policy Process

The Module is offered two-yearly in spring semester. The module is offered again in the spring semester of 2025.

➤➤ Impact Analysis

The Module is offered two-yearly in spring semester. The module is offered again in the spring semester of 2026.

➤ Electives

MAS students can choose from the Science in Perspective course offer or related courses. Enrollment only after agreement with the TPP Programme Leadership.

➤ Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>877-0400-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>15</td>
<td>D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract

The MAS students focus on a specific policy problem and carry out a policy analysis either within an ETH research group or with a project partner from the public, private or civic sector. In either case, the policy analysis project requires an ETH professor as supervisor, who is also responsible for grading the thesis.

Objective

Apply the policy analysis skills acquired throughout the MAS TPP programme.

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed

Personal Competencies

- Critical Thinking: assessed

MAS in Technology and Public Policy - Key for Type

| O   | Compulsory       | E-   | Recommended, not eligible for credits |
| W+  | Eligible for credits and recommended | Z    | Courses outside the curriculum |
| W   | Eligible for credits | Dr   | Suitable for doctorate |

Key for Hours

V: lecture  
G: lecture with exercise  
U: exercise  
S: seminar  
K: colloquium  
P: practical/laboratory course  
A: independent project  
D: diploma thesis  
R: revision course / private study

ECTS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Urban and Territorial Design

The MAS in Urban and Territorial Design requires one year of full-time postgraduate study for a 60 ECTS joint degree, the “MAS ETH EPF UTD”. It is taught in English and held at the two Swiss schools, EPFL (Autumn) and ETH Zurich (Spring).

Design Studio and Postproduction

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>078-0100-00L</td>
<td>Core Design and Research Studio I (EPFL)</td>
<td>O</td>
<td>17</td>
<td>17G</td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecturers: P. Viganò with C. Fivet, L. Rossi and guests. The Core Studio will reflect on the “transition”, assuming its multiple dimensions (ecological, social and economic) and developing transcultural design operations in concrete territories. The territory of Greater Geneva will be the test-bed for radical design explorations of possible futures.</td>
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<tr>
<td>Objective</td>
<td>Different urban conditions will be considered in order to understand, read and manage the thick complexity of the contemporary habitat where densities, distances, relations and practices shape heterogeneous spaces and ecologies. Conceived as a place of interaction among disciplines, the studio also constitutes the main tool to develop interdisciplinarity within the design practice.</td>
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<tr>
<td>Content</td>
<td>A series of lectures will deal with ecology; the organism and its environment; population and community ecology; and biodiversity. Others lectures on design as knowledge production and on representation—GIS, video and photography—will be embedded within the activities of the studio. Fieldwork is integral to the design studio.</td>
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<tr>
<td>078-0101-00L</td>
<td>Postproduction I (EPFL)</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecturer: P. Viganò. The last period of the semester in January will consist of a post-production session, related to the results at EPFL. It mainly concerns the products of the Core Studio, but will also be implemented by the associated teaching.</td>
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<tr>
<td>Objective</td>
<td>All research and design materials produced during the studio, courses and sessions (e.g. texts, maps, drawings, etc.) will be evaluated, edited and curated in a “Semester Report” by the core teaching team and a graphic designer. At the end, the “Report” will be available online.</td>
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Interdisciplinary Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>078-0200-00L</td>
<td>City, Habitat and Mobility (EPFL)</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecturers: V. Kaufmann with L. Pattaroni. The course aims to understand the political and social conditions of urban lifestyles and mobilities patterns in order to explore the levers of action available to professionals to support the critical emergence of renewed urban models.</td>
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<tr>
<td>Objective</td>
<td>Taking the form of a course - seminar, the proposed teaching aims to show the interest of methodologies from the social sciences of the city to develop critical urban and territorial design. Planned to last 12 weeks, it proposes to take up each week a theme related to the relation between city, habitat, and mobility.</td>
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<tr>
<td>Content</td>
<td>Each session is organized in two parts: (1) a presentation by one of the students of an article on the week’s theme, followed by a discussion, and (2) a presentation by the teaching team to identify the knowledge and debates of social sciences related to urban and territorial design issues. Two sessions will be devoted to field visits.</td>
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<tr>
<td>078-0201-00L</td>
<td>Circularity, Materials &amp; Flows (EPFL)</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecturer: C. Fivet. The circular economy consists in maintaining the value of products as long as possible by extending or renewing their service life while minimizing resource depletion, waste and greenhouse gas emissions. The integration of these principles in the construction industry has many facets that often contradict each other.</td>
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<tr>
<td>Objective</td>
<td>While introducing students to the concept of the circular economy and its applications to building design, the class provides ready-to-use techniques and aims at developing a critical mindset towards their use. Following a ’flipped classroom’ methodology, the class devies into recent literature and practice by means of adversarial open debates. Examination consists in the writing of a short personal essay on a chosen topic and its oral defence.</td>
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<tr>
<td>078-0202-00L</td>
<td>Landscapes &amp; Ecosystems (EPFL)</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecturer: L. Rossi. This course addresses water management from a global point of view, including in particular the impacts of rain discharges on receiving environments. The qualitative aspects (risk of contamination) are considered as a priority, in parallel with the quantitative risks (floods).</td>
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<tr>
<td>Objective</td>
<td>The course aims to understand the means and issues of management and maintenance of sewerage systems, finalized to the control of impacts in receiving environments, and more generally to raise the importance of hydraulic management in the urban and territorial project.</td>
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<tr>
<td>Content</td>
<td>General introduction - Legislative aspects related to urban hydrology - Simplified design methods and technical solutions: from source control to solutions at the end of the network - Field visits</td>
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<tr>
<td>078-0207-00L</td>
<td>Systems Thinking in the Age of Transition (EPFL)</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>external organisers</td>
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Urban Theory Sessions

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>078-0300-00L</td>
<td>Urban &amp; Environmental Theory Session (EPFL)</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecturers: S. Marot and guests. As a guiding principle that remains to be defined, the transition can be critically confronted with broader histories of the environment. The various and even very opposite hypotheses it contains will be differentiated and deepened in the module. In particular that of autonomy will be discuss regarding to the so-called &quot;secesssion&quot; scenario.</td>
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<tr>
<td>Objective</td>
<td>This session aims to understand how and to what extent environmental concerns can influence urban and territorial design. From a critical point of view, it also intends to question the notion of transition under the prism of its antecedents in ecological thinking.</td>
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MAS in Urban and Territorial Design - Key for Type

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<th>Notes</th>
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<tbody>
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<td>O</td>
<td>Compulsory</td>
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<td>W+</td>
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<td>W</td>
<td>Eligible for credits</td>
<td>Suitable for doctorate</td>
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<td>Key for Hours</td>
<td>Description</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS Mediation in Peace Processes

Module 1: Mediation in Context

Does not take place this semester.

Abstract
This module defines and contextualises peace mediation in relation to other conflict resolution approaches. The module focuses heavily on conflict analysis, introducing the students to the latest knowledge about conflict typologies, trends, and causes in addition to providing them with various opportunities to practice conflict analysis using diverse methods.

Objective
This module defines and contextualises peace mediation in relation to other conflict resolution approaches. The module focuses heavily on conflict analysis, introducing the students to the latest knowledge about conflict typologies, trends, and causes in addition to providing them with various opportunities to practice conflict analysis using diverse methods.

Module 4: Mediation Process Design

Abstract
Mediators help the parties reach a peace agreement by designing and structuring the process. This module covers the basic elements of process design and how they differ. Important to process design is the reflection on theory and practice in sequencing the content to be examined. The module then explores the implications and challenges facing the implementation of peace agreements for mediators.

Objective
Mediators help the parties reach a peace agreement by designing and structuring the process. This module covers the basic elements of process design and how they differ. Important to process design is the reflection on theory and practice in sequencing the content to be examined. The module then explores the implications and challenges facing the implementation of peace agreements for mediators.

MAS Mediation in Peace Processes - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The course is based on "Chemistry: The Central Science" by Brown, LeMay, Bursten, Murphy, Woodward, and Stoltzfus. Pearson, 15th

Lecture slides and all other material will be made available for download on the course web page.

Electronic structure of atoms, chemical bonding, molecular geometry and bonding theories, intermolecular forces, gases, thermodynamics,

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### First Year Examinations

#### First Year Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0261-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>A. Steiger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Functions; Differential and integral calculus for functions of one variable; power series. The mathematical methods are applied in a large number of examples from mechanics, physics and other areas which are basic to engineering.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Introduction to the mathematical foundations of engineering sciences, as far as concerning differential and integral calculus in one variable,</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>U. Stammbach: Analysis I/II</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Exercises and online quizzes are an important aspect of this course. Attempts at solving these problems will be honored with a bonus on the final grade. See &quot;Performance assessment&quot; for more information.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
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<tr>
<td></td>
<td>Concepts and Theories</td>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td></td>
<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<tr>
<td></td>
<td>Problem-solving</td>
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#### First Year Examination Block B

<table>
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<tr>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0832-00L</td>
<td>Computer Science I</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>C. Cotrini Jimenez, R. Sasse</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.</td>
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<tr>
<td>Objective</td>
<td>Primary educational objective is to learn programming with C++. When successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens &quot;behind the scenes&quot; when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking of a computer scientist.</td>
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<tr>
<td>Content</td>
<td>The course covers fundamental data types, expressions and statements, (Limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism, simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture slides and all other material will be made available for download on the course web page.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
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<td>Techniques and Technologies</td>
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<tr>
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<td>Method-specific Competencies</td>
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<tr>
<td></td>
<td>Analytical Competencies</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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<tr>
<td></td>
<td>Problem-solving</td>
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<table>
<thead>
<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0090-00L</td>
<td>Chemistry</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>D. J. Norris</td>
</tr>
<tr>
<td>Abstract</td>
<td>This is a general chemistry course aimed at first-year bachelor students in the Department of Mechanical and Process Engineering.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The aims of the course are: 1) To provide a thorough understanding of the basic principles of chemistry and its application, 2) To develop an understanding of the atomic and molecular nature of matter and of the chemical reactions that describe its transformations, and 3) To emphasize areas considered most relevant in an engineering context.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Electronic structure of atoms, chemical bonding, molecular geometry and bonding theories, intermolecular forces, gases, thermodynamics, chemical thermodynamics, chemical kinetics, equilibria, liquids and solutions, acids and bases, redox- and electrochemistry.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>The instructor's lecture notes will be available prior to every lecture and can be downloaded from Moodle.</td>
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</tbody>
</table>

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**Data: 02.07.2024 12:39**

**Autumn Semester 2024**

**Page 1731 of 2667**
Content
Systems of linear equations, Gaussian elimination, solution space, matrices, LR decomposition, Determinants, structure of linear spaces, normed vector spaces, inner products, method of least squares, QR decomposition, introduction to MATLAB, applications

Literature
* K. Meyberg / P. Vachenauer, Höhere Mathematik 1, Springer 2003

Prerequisites / notice
Active participation in the exercises is part of this course. It is expected, that students submit 3/4 of all exercises for control.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Conceptual Competencies</th>
<th>fostered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
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</tr>
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</table>

Additional First Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0321-00L</td>
<td>Engineering Design and Material Selection</td>
<td>O</td>
<td>4</td>
<td>4G</td>
<td>K. Shea, T. Stankovic</td>
</tr>
</tbody>
</table>

Abstract
This course provides an introduction to engineering design. Through hands-on, practice-oriented exercises, students learn about and experience the fundamentals of engineering design, including concept design, technical drawing, CAD, material selection, manufacturing process selection and sustainability. Three case studies in healthcare, mobility and sustainable materials are explored.

Objective
The lecture and exercises teach the fundamentals of engineering design, technical drawing and CAD as well as material selection. After taking the course, students will be able to tackle simple design tasks, generate and evaluate concepts, accurately create technical drawings of parts and assemblies as well as read them. Students will also be able to create models of parts and assemblies in a 3D, feature-based CAD system. They will understand the links between engineering design, sustainability, material selection and manufacturing process selection.

Content
Introduction to Engineering Design
- design requirements
- concept generation and selection
- prototyping

Design Representations
- Sketching in Engineering Design
- Technical Drawing:
  - projections, views and cuts
  - dimensioning
  - assemblies
- CAD:
  - CAD modeling operations
  - parametric design and feature-based modeling
  - assemblies
  - creating 2D drawings from 3D part models

Fabrication and Additive manufacturing

Design for the Environment
Material and Manufacturing Process Selection
- materials and their properties, with emphasis on sustainable materials
- basic mechanics
- material selection processes
- manufacturing process selection

Three case studies in healthcare, mobility and sustainable materials

Lecture notes
Lecture slides and exercise handouts are available on the course Moodle website: https://moodle-app2.let.ethz.ch/course/view.php?id=17403

Literature
All literature will be given on the Moodle website: https://moodle-app2.let.ethz.ch/course/view.php?id=17403

Prerequisites / notice
This course is given as a lecture (1h/week) and an exercise (3h/week). Students are split into working groups for the exercises with a maximum of 20 students per group.

Semester Fee: A fee is charged for printed copies of the course handouts and 3D printing (the 3D-Car project). The fee is 14.- CHF per student.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Conceptual Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<tr>
<td></td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
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</tr>
<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>
Additional Project  
ONLY for Mechanical Engineering BSc, Programme Regulations 2022.

Enrollment only in consultation with the D-MAVT student administration.

Abstract  
Additional Project

Objective  
Compensation of missing credit points due to transition between regulations.

### Second and Third Year Compulsory Courses

#### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0503-00L</td>
<td>Mechanics III</td>
<td>O</td>
<td>6</td>
<td>4V+2U</td>
<td>D. Kochmann</td>
</tr>
</tbody>
</table>

**Abstract**  
Dynamics of particles, rigid bodies, and deformable bodies: Motion of a single particle, motion of systems of particles, 2D and 3D motion of rigid bodies, vibrations, waves.

**Objective**  
This course enables students to apply the concepts and laws governing the kinematics and kinetics of particles, rigid bodies, and elastic bodies in order to identify, formulate, and solve dynamical engineering problems. Specifically, students will be able to describe, analyze, and predict the motion of particles and bodies in space over time and to relate their motion to the applied forces for applications in (not only) mechanical and civil engineering.

**Content**  
Students of mechanical and civil engineering learn the fundamental concepts of the dynamics of mechanical systems. By studying the motion of a single particle, systems of particles, of rigid bodies, and of deformable bodies, we introduce essential concepts such as kinematics, kinetics, work and energy, equations of motion, and forces and torques. Further topics include the stability of equilibria and vibrations as well as an introduction to the dynamics of deformable bodies and waves in elastic rods. Throughout the course, application-oriented examples help students acquire a proficient background in engineering dynamics, further to learn and embrace problem-solving techniques for dynamical engineering problems, gain cross-disciplinary expertise (by linking concepts from, among others, mechanics, mathematics, and physics), and prepare students for advanced courses and work on engineering applications. The detailed syllabus includes:

1. Motion of a single particle: kinematics (trajectory, velocity, acceleration), forces and torques, constraints, active and reaction forces, balance of linear and angular momentum, work-energy balance, conservative systems, equations of motion.
2. Motion of systems of particles: internal and external forces, balance of linear and angular momentum, work-energy balance, rigid systems of particles, particle collisions, mass accretion/loss.
3. Motion of rigid bodies in 2D and 3D: kinematics (angular velocity, velocity and acceleration transfer, instantaneous center and axis of rotation), balance of linear and angular momentum, work-energy balance, angular momentum transport, inertial vs. moving reference frames, apparent forces, Euler equations.
5. Introduction to waves and vibrations of elastic bodies: local form of linear momentum balance, waves in slender elastic rods.

**Lecture notes**  
Lecture notes (a complete scriptum) is available on Moodle. Students are encouraged to take their own notes during class.

**Literature**  
Lecture notes (a complete scriptum) is available on Moodle. Further reading materials are suggested but not required for this class.

**Prerequisites / notice**  
For students in the bachelor's degree programme in mechanical engineering:
Precondition for this course unit are passed first year examination blocks A and B.

**Competencies**  
All course materials (including lecture notes, exercise problems, etc.) are available on Moodle.

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories assessed</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
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<table>
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<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies assessed</th>
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<tr>
<td>Decision-making</td>
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</tr>
<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<td>Cooperation and Teamwork fostered</td>
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<td>Sensitivity to Diversity fostered</td>
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<th>Personal Competencies</th>
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<td>Creative Thinking fostered</td>
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<td></td>
<td>Critical Thinking assessed</td>
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### Additional Project

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<th>Number</th>
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<tr>
<td>151-0591-00L</td>
<td>Control Systems I</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>E. Frazzoli</td>
</tr>
</tbody>
</table>

**Abstract**  
Objective
The course addresses dynamic control systems, i.e., systems that (i) evolve over time, and (ii) have control inputs and measured outputs. The main objective is to learn how to design the control inputs in such a way that the measured outputs have some desirable properties. For example, for an advanced driver assistance system, how to control acceleration so that the speed remains constant, and how to control the steering angle so that the car remains in the center of the lane.

In order to pursue this objective, the course is organized into three main parts:

1) Modeling: learn how to represent a dynamic control system in such a way that it can be treated effectively using computational and mathematical tools. This will include learning how to use computer tools like Matlab to simulate dynamic control systems.

2) Analysis: understand the basic characteristics of a system, such as its (internal and external) stability, performance, and robustness, and how the input affects the output. We will also learn to analyze systems obtained as interconnections (e.g., feedback) of two or more other systems. In particular, we will focus on tools that allow to understand how a system will behave under feedback control (i.e., closed-loop behavior), based only on its open-loop behavior.

3) Synthesis: the last part of the course will concentrate on how to design feedback control laws, in order to change the behavior of the system in a desirable way.

In this course, we will concentrate on systems that can be modeled by Ordinary Differential Equations (ODEs), and that satisfy certain other technical conditions, such as linearity and time-invariance. In addition, we will focus on systems with a Single Input and a Single Output (SISO).

This will allow us to use "classical control" tools that are very powerful and easy to use (i.e., mostly graphical), and which are really laying the foundation of any followup work on more challenging control problems.

In addition to paper-and-pencil techniques, we will leverage modern computational tools for control design, such as Matlab.

Prerequisites / notice
Basic knowledge of (complex) analysis and linear algebra.
Familiarity with Matlab is recommended.
For students in the bachelor's degree programme in mechanical engineering: Precondition for this course unit are passed first year examination blocks A and B.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed

Lecture notes
Lecture slides and additional material will be posted online.

Literature
There is no required textbook.

A nice introductory book on feedback control, available online for free, is:
Feedback Systems: An Introduction for Scientists and Engineers
Karl J. Astrom and Richard M. Murray

http://www.cds.caltech.edu/~murray/amwiki/index.php/First_Edition

Prerequisites / notice
For students in the bachelor's degree programme in mechanical engineering:
Precondition for this course unit are passed first year examination blocks A and B.

Competencies

151-0051-00L Thermodynamics I
O 4 credits 2V+2U A. Bardow, C. Müller
Introduction to the fundamentals of technical thermodynamics.

1. Konzepte und Definitionen
2. Der erste Hauptsatz, der Begriff der Energie und Anwendungen für geschlossene Systeme
3. Eigenschaften reiner kompressibler Substanzen, quasi-statische Zustandsänderungen
4. Elemente der kinetischen Gastheorie
5. Der erste Hauptsatz in offenen Systemen - Energieanalyse in einem Kontrollvolumen
6. Der zweite Hauptsatz - Der Begriff der Entropie
7. Nutzbarkeit der Energie - Exergie
8. Thermodynamische Beziehungen für einfache, kompressible Substanzen.

Lecture notes available

Literature

Prerequisites / notice
For students in the bachelor's degree programme in mechanical engineering:
Precondition for this course unit are passed first year examination blocks A and B.

227-0075-00L Electrical Engineering I
O 4 credits 2V+2U J. Leuthold
Basic course in electrical engineering with the following topics: Concepts of voltage and currents; Analyses of dc and ac networks; Series and parallel resistive circuits, circuits including capacitors and inductors; Kirchhoff’s laws and other network theorems; Transient responses; Basics of electrical and magnetic fields;

Objective
Understanding of the basic concepts in electrical engineering with focus on network theory. The successful student knows the basic components of electrical circuits and the network theorems after attending the course.
Diese Vorlesung vermittelt Grundlagenkenntnisse im Fachgebiet Elektrotechnik. Ausgehend von den grundlegenden Konzepten der Spannung und des Stroms wird die Analyse von Netzwerken bei Gleich- und Wechselstrom behandelt. Dabei werden folgende Themen behandelt:

Kapitel 1 Das elektrostatische Feld
Kapitel 2 Das stationäre elektrische Strömungsfeld
Kapitel 3 Einfache elektrische Netzwerke
Kapitel 4 Halbleiterbauelemente (Dioden, der Transistor)
Kapitel 5 Das stationäre Magnetfeld
Kapitel 6 Das zeitlich veränderliche elektromagnetische Feld
Kapitel 7 Der Übergang zu den zeitabhängigen Strom- und Spannungsformen
Kapitel 8 Wechselspannung und Wechselstrom

Lecture notes
Die Vorlesungsschriften werden auf Moodle bereitgestellt.

Literature
Als ausführliches Skript wird das Buch "Manfred Albach. Elektrotechnik, Person Verlag, Ausgabe vom 1.8.2011" empfohlen.

Prerequisites / notice
Für das weitergehende Studium werden in der Vorlesung verschiedene Bücher vorgestellt.

Abstract
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

Content
Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac’s Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D’Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates; Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Lecture notes
Lecture notes by Prof. Dr. Alessandra Iozzi: https://polybox.ethz.ch/index.php/s/D3K0TayQXvfpCAA

Literature
For reference/complement of the Analysis I/II courses:

Prerequisites / notice
For students in the bachelor’s degree programme in mechanical engineering:
Precondition for this course unit are passed first year examination blocks A and B.

Examination Block 2
Offered in the spring semester only

Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0300-10L</td>
<td>Innovation Project</td>
<td></td>
<td>3 credits</td>
<td>3U</td>
<td>M. Meboldt</td>
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</table>

Abstract
The students are going through a product development process starting with the first idea to the functional product. The participants will learn to work on a complex development task in a team (5 pers.), to structure a given problem, to generate and evaluate ideas as well as the design and realization of the product with subsequent verification.

Objective
The students learn and experience the principles of product development. In addition to acquiring development methodical responsibilities, the main focus is on working together as a team. The participants are taught how to structure a complex development objective and how to achieve this objective in team work. In the end, the students will master the basics of development processes and development methodical tools.
### Electives

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0221-00L</td>
<td>Introduction to Modeling and Optimization of Sustainable Energy Systems</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>G. Sansavini, A. Bardow, S. Moret</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.</td>
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<td><strong>Objective</strong></td>
<td>At the end of this course, students will be able to:</td>
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<td>- define and quantify the key performance indicators of sustainable energy systems;</td>
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<td>- select and apply appropriate models for conversion, storage and transport of energy;</td>
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<td>- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;</td>
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<td>- select and apply methodologies for the uncertainty analysis on energy systems models;</td>
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<td>- apply the acquired knowledge to tackle the challenges of the energy transition.</td>
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<td><strong>Content</strong></td>
<td>In the course “Introduction to Modeling and Optimization of Sustainable Energy Systems”, the competencies of process understanding, system understanding, modeling, concept development, data analysis &amp; interpretation and measurement methods are taught, applied and examined. Programming is applied.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>The global energy transition; Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.</td>
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<tr>
<td>151-0533-00L</td>
<td>Introduction to Computing</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>L. De Lorenzis</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>The course provides a broad introduction to modern techniques in scientific computing, useful for tasks ranging from data analysis to model building to engineering computations. For each topic, a solid theoretical foundation is combined with extensive exposure to practical multidisciplinary examples and with coding exercises.</td>
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<td><strong>Objective</strong></td>
<td>After taking this class, students will be able to apply numerical techniques including interpolation, transforms, differentiation, integration and solution techniques for linear and non-linear equation systems to extract fundamental information from data and to model, approximate and solve a number of complex problems in engineering and across disciplines.</td>
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<td><strong>Lecture notes</strong></td>
<td>Lecture notes will be provided, however, students are also encouraged to take their own notes.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Relevant references will be provided.</td>
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<tr>
<td>151-0575-01L</td>
<td>Signals and Systems</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>A. Carron</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.</td>
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<td><strong>Objective</strong></td>
<td>Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.</td>
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<td><strong>Content</strong></td>
<td>Discrete-time signals and systems. Fourier- and z-Transforms. Frequency domain characterization of signals and systems. System identification. Time series analysis. Filter design.</td>
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<td><strong>Lecture notes</strong></td>
<td>Lecture notes available on course website.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Control Systems I is helpful but not required.</td>
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<tr>
<td>151-0700-00L</td>
<td>Manufacturing</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Bambach, M. Afrasiabi</td>
</tr>
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<td><strong>Abstract</strong></td>
<td>Fundamental terms of productions engineering, plastic deformation, machining, Lasermachining, Mechatronic in the productions machine construction, Quality assurance, Process chain planning.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>- Knowledge of principal terms of manufacturing engineering</td>
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<td></td>
<td>- Basic knowledge of some processes, their mode of operation and design (forming, separative processes, Laser technologies)</td>
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<td>- Knowledge of product defining properties and limitations of applications</td>
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<td>- In competition of processes make the right decisions</td>
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<td>- Procedure for process chain planning</td>
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<td>- Basic knowledge for quality assurance</td>
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<tr>
<td><strong>Content</strong></td>
<td>Explanation of basic principles of manufacturing technics and insight into the functionality of a manufacturing shop. Plastic deformation- and separative- manufacturing processes, as well as laser machining (welding and cutting), and their layouts, product defining properties and limitations of applications such as the associated workshop facilities, will be introduced in different details. Further basic principles of the industrial measurement technique and mechatronics concepts in machine tool construction will be discussed.</td>
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<td>151-0851-00L</td>
<td>Robot Dynamics</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Hutter, R. Siegwart, J. Tordesillas Torres</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The course consists of three parts: First, we will refresh and deepen the student’s knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.</td>
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<td><strong>Prerequisites / notice</strong></td>
<td>The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.</td>
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<td>151-0913-00L</td>
<td>Introduction to Photonics</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>R. Quidant, J. Ortega Arroyo</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.</td>
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</table>
Objective

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.

Content

I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel coefficients
3) Total internal reflection
4) Evansen waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Applications of optical tweezers

VII- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving

Personal Competencies
Creative Thinking
Critical Thinking

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.

Content
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature
### 151-0973-00L Introduction to Process Engineering

**Abstract**
Overview of process engineering; fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

**Objective**
We teach the fundamentals of process engineering using practical examples as well as concrete process engineering problems in the areas of process control and balancing, thermal separation processes, mechanical separation processes and reaction engineering.

**Content**
Overview of process engineering; fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

**Competition**
In addition to teaching basic theoretical knowledge, the focus is on solving typical problems in various subdisciplines of process engineering.

**Lecture notes**
A script is provided (German language).

**Literature**
Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the lecture and the exercise materials are sufficient.

### 151-3207-00L Lightweight Structures

**Abstract**
The elective course Lightweight includes numerical methods for the analysis of the load carrying and failure behavior of lightweight structures, as well as construction methods and design principles for lightweight design.

**Objective**
The goal of this course is to convey substantiated background for the understanding and the design and sizing of modern lightweight structures in mechanical engineering, vehicle and airplane design.

**Content**
Lightweight design
Thin-walled beams and structures
Instability behavior of thin walled structures
Reinforced shell structures
Load introduction in lightweight structures
Joining technology
Sandwich design

**Lecture notes**
Handouts, Exercises

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methodspecific Competencies</th>
<th>Literature</th>
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</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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### 351-0511-00L Managerial Economics

**Abstract**
Not for MSc students belonging to D-MTEC!

"Managerial Economics" provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

**Objective**
The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

**Literature**

**Prerequisites / notice**
The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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### Focus Project

*In addition to the focus project, 8 ECTS must be acquired as focus courses. Choose these subjects in consultation with the professor responsible for your focus project from the categories of "Electives" and "Focus Specialization".*

**Number**

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0073-10L</td>
<td>MONKEE</td>
<td>W</td>
<td>0</td>
<td>R. Siegwart</td>
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</tbody>
</table>

*This course is part of a one-year course. The 20 credit points will be issued at the end of FS2025 with new enrolling for the same Focus Project in FS2025.*
For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:

a. First year examinations successfully passed.
b. Block 1 and 2 successfully passed.

Abstract

Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective

The various objectives of the Focus Project are:

- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Prerequisites / notice

Participation in the Focus Rollout is part of the Focus Project.

151-0073-20L ReefRanger

This course is part of a one-year course. The 20 credit points will be issued at the end of FS2025 with new enrolling for the same Focus Project in FS2025.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:

a. First year examinations successfully passed.
b. Block 1 and 2 successfully passed.

Abstract

Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective

The various objectives of the Focus Project are:

- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Prerequisites / notice

Participation in the Focus Rollout is part of the Focus Project.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-direction and Self-management assessed

151-0073-40L Extraterrestrial Surface Exploration Robot

This course is part of a one-year course. The 20 credit points will be issued at the end of FS2025 with new enrolling for the same Focus Project in FS2025.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:

a. First year examinations successfully passed.
b. Block 1 and 2 successfully passed.

Abstract

Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).
Objective
The various objectives of the Focus Project are:
- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Prerequisites / notice
Participation in the Focus Rollout is part of the Focus Project.

151-0073-50L Underwater Swarm Robotics

This course is part of a one-year course. The 20 credit points will be issued at the end of FS2025 with new enrolling for the same Focus Project in FS2025.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
- a. First year examinations successfully passed.
- b. Block 1 and 2 successfully passed.

Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
The various objectives of the Focus Project are:
- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Prerequisites / notice
Participation in the Focus Rollout is part of the Focus Project.

151-0075-10L Modular Evolving Industrial Robots

This course is part of a one-year course. The 20 credit points will be issued at the end of FS2025 with new enrolling for the same Focus Project in FS2025.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
- a. First year examinations successfully passed.
- b. Block 1 and 2 successfully passed.

Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
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- Independence, initiative, independent learning of new topic contents
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<thead>
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Prerequisites for the focus projects:

a. First year examinations successfully passed.
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Abstract

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Participation in the Focus Rollout is part of the Focus Project.

### Focus Specialization

#### Sustainable Energy and Processes

**Focus Coordinator:** Prof. Mark Tibbitt

In order to achieve the required 20 credit points for the Focus Specialization Sustainable Energy and Processes you need to pass at least 2 core courses (W+) and at least 2 of the elective courses, according to the presentation of the Focus Specialization. An additional course, if needed, can be selected among the courses offered by D-MAVT (151-…).

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<th>Number</th>
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<td>151-0917-00L</td>
<td>Mass Transfer</td>
<td>W+</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>M. Tibbitt, V. Mavrantzas, C.-J. Shih</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.</td>
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<td>Content</td>
<td>Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.</td>
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<td>Media and Digital Technologies</td>
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<td>Sensitivity to Diversity</td>
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<td>Self-direction and Self-management</td>
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| 151-0973-00L | Introduction to Process Engineering | W+   | 4 credits | 2V+2U | F. Donat, C. Müller |
| Abstract     | Overview of process engineering; fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times. |
| Objective    | We teach the fundamentals of process engineering using practical examples as well as concrete process engineering problems in the areas of process control and balancing, thermal separation processes, mechanical separation processes and reaction engineering. |
| Content      | Overview of process engineering; fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times. In addition to teaching basic theoretical knowledge, the focus is on solving typical problems in various subdisciplines of process engineering. |
| Lecture notes | A script is provided (German language). |
| Literature   | Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the lecture and the exercise materials are sufficient. |

| 151-0123-00L | Experimental Methods for Engineers | W+   | 4 credits | 2V+2U | D. J. Norris, F. Coletti, M. Lukatskaya, A. Manera, O. Supponen, M. Tibbitt |
| Abstract     | Does not take place this semester. |
|              | The course presents an overview of measurement tasks in engineering environments. Different concepts for the acquisition and processing of typical measurement quantities are introduced. Following an initial in-class introduction, laboratory exercises from different application areas (especially in thermofluidics, energy, and process engineering) are attended by students in small groups. |
Introduction to various aspects of measurement techniques, with particular emphasis on thermo-fluidic, energy, and process-engineering applications.

Understanding of various sensing technologies and analysis procedures.

Study of applications in the laboratory. Fundamentals of scientific documentation and reporting.

In-class introduction to representative measurement techniques in the research areas of the participating institutes (fluid dynamics, energy technology, and process engineering).

Lab reports for all attended experiments have to be submitted by the study groups.

Lecture notes
Presentations, handouts, and instructions are provided for each experiment.

Literature

Basic understanding in the following areas:
- fluid mechanics, thermodynamics, heat and mass transfer
- electrical engineering / electronics
- numerical data analysis and processing (e.g. using MATLAB)

The course gives an overview on the following topics: basics of hydrodynamics, capillarity, hydrodynamic instabilities, liquid fragmentation.

This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

Student participation in ~6 laboratory experiments (study groups of ~3 students, dependent on the number of course participants and available experiments).

Lecture notes
Class notes and handouts

Literature

This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

The main learning objectives of this course are:
1. Identify and describe dominant effects in liquid fluid flows through physical modelling.
2. Identify and predict the onset of hydrodynamic instabilities.
3. Describe acoustic wave behaviour in liquids.
4. Explain tension, nucleation and phase-change in liquids.
5. Predict the behaviour of a gas bubble subject to changes in surrounding liquid pressure.
6. Describe hydrodynamic cavitation and its consequences in physical terms.
7. Recognise experimental techniques and industrial and medical applications for cavitation.
8. Read and evaluate research papers on recent research on cavitation and bubble dynamics and communicate the content orally to a multidisciplinary audience.

This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

The course gives an overview on the following topics: basics of hydrodynamics, capillarity, hydrodynamic instabilities, liquid fragmentation. Acoustics in liquids, tension in liquids, phase change. Cavitation and bubble dynamics: single bubbles (nucleation, dynamics, collapse), bubble clouds and cavitating flows. Industrial applications and measurement techniques.

Class notes and handouts

Literature
Fluid dynamics I & II or equivalent

This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

The course gives an overview on the following topics: basics of hydrodynamics, capillarity, hydrodynamic instabilities, liquid fragmentation. Acoustics in liquids, tension in liquids, phase change. Cavitation and bubble dynamics: single bubbles (nucleation, dynamics, collapse), bubble clouds and cavitating flows. Industrial applications and measurement techniques.

Class notes and handouts

Literature
Fluid dynamics I & II or equivalent

This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

The course gives an overview on the following topics: basics of hydrodynamics, capillarity, hydrodynamic instabilities, liquid fragmentation. Acoustics in liquids, tension in liquids, phase change. Cavitation and bubble dynamics: single bubbles (nucleation, dynamics, collapse), bubble clouds and cavitating flows. Industrial applications and measurement techniques.

Class notes and handouts

Literature
Fluid dynamics I & II or equivalent
Abstract
Physical fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding

Objective
Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.

Content
Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of reactor technology.

Lecture notes
Hand-outs will be distributed. Additional literature and information on the website of the lab: https://www.ethz.ch/content/specialinterest/mavt/energy-technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00l-nuclear-energy-conversion.html

Literature

R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

151-0215-00L Fundamentals of Acoustics W 4 credits 3G N. Noiray, B. Van Damme
Abstract
This course provides an introduction to acoustics. It focusses on fundamental phenomena of airborne and structure-borne sound waves. The lecture combines theoretical principles with practical insights and interpretations.

Objective
This course is proposed for Master and PhD students interested in getting knowledge in acoustics. Students will be able to understand, describe analytically and interpret sound generation, absorption and propagation.

Content
First, magnitudes characterizing sound propagation are reviewed and the constitutive equations for acoustics are derived. Then the different types of sources (monopole/dipole/quadrupole, punctual, non-compact) are introduced and linked to the noise generated by turbulent flows, coherent vortical structures or fluctuating heat release. The scattering of sound by rigid bodies is given in basic configurations. Analytical, experimental and numerical methods used to analyze sound in ducts and rooms are presented (Green functions, Galerkin expansions, Helmholtz solvers).

Lecture notes
Handouts will be distributed during the class

Literature
Books will be recommended for each chapter

151-0221-00L Introduction to Modeling and Optimization of Sustainable Energy Systems W+ 4 credits 4G G. Sansavini, A. Bardow, S. Moret
Abstract
This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.

Objective
At the end of this course, students will be able to:
- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

In the course “Introduction to Modeling and Optimization of Sustainable Energy Systems”, the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

Content
The global energy transition: Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.

Lecture notes
Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

151-0293-00L Fundamentals and Applications of Combustion W 4 credits 2V+1U+2A N. Noiray, F. Ernst, C. E. Frouzakis
Note: The previous course title until HS23: "Combustion and Reactive Processes in Energy and Materials Technology"

Abstract
This course will provide an introduction to the fundamentals and the applications of combustion in energy conversion and nanoparticles synthesis. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

Objective
The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

Content

Lecture notes
No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Teaching language, assignments and lecture slides in English

Literature

Objective

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.

Content

I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel coefficients
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Applications of optical tweezers

VII- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving

Personal Competencies
Creative Thinking
Critical Thinking

151-0941-00L Molecular Sensors: From Fundamentals to Health and Environmental Applications

W 4 credits 2V+2U
A. Güntner, P. Gerber

Note: previous course title until HS23 "Molecular Health Sensors and Devices"

Abstract
Molecular sensors are used in everyday life in health care, environmental monitoring, food safety, space and other fields. Sources of molecular information, its transport and fundamental concepts of molecular sensing will be discussed. In the scope of group projects, the acquired knowledge will be applied and deepened in case studies.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1746 of 2667
Objective After the course, the students will:

- know the requirements and merits of molecular sensors for health, environmental and other emerging applications (e.g. space)
- understand transport phenomena of molecular information & surface interactions and know how to quantitatively describe these
- understand fundamental sensing concepts for the detection and quantification of molecular analytes
- know concepts of signal processing
- be capable to apply the learnt knowledge to conceive and engineer sensor concepts and systems
- know how to investigate sensor-related literature and present scientific data

This course consists of a theoretical and a project-based learning block. In the first 10 semester weeks, theoretical knowledge will be provided through lectures and deepened in corresponding exercises. In the last 4 weeks, the students will apply the learned concepts through group projects to investigate case studies. The outcome will be present.

Content Transport of Molecular Information; Surface Interactions; Sensor Fundamentals; Chemoresistive Sensing; Electrochemical Sensing; Mass-sensitive; Capacitive Sensing; Signal Processing; Medical Requirements for Molecular Sensing

Lecture notes Hand-outs will be provided to each lecture including the exercises and their solutions.

Compeptencies Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Leadership and Responsibility fostered
- Sensitivity to Diversity fostered

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection fostered

Robotic, Systems, and Control
Focus Coordinator: Prof. Robert Katzschmann

Number Title Type ECTS Hours Lecturers

151-0509-00L Acoustics in Fluid Media: From Robotics to Additive Manufacturing W 4 credits 3G D. Ahmed

Abstract The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices


Prerequisites / notice Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions ( both compulsory) and hand in homework.

Compeptencies Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-direction and Self-management assessed

151-0575-00L Signals and Systems W 4 credits 2V+2U A. Carron

Abstract Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

Objective Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.


Lecture notes Lecture notes available on course website.

Prerequisites / notice Control Systems I is helpful but not required.
### 151-0604-00L  
**Microrobotics**  

<table>
<thead>
<tr>
<th>Credit Type</th>
<th>Credits</th>
<th>Semester</th>
<th>Supervisor</th>
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<tbody>
<tr>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
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</table>

**Abstract**  
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**  
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

**Content**  
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

**Lecture notes**  
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

**Prerequisites / notice**  
The lecture will be taught in English.

### 151-0602-00L  
**Microsystems I: Process Technology and Integration**

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<th>Semester</th>
<th>Supervisor</th>
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<tbody>
<tr>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>M. Haluska, C. Hierold</td>
</tr>
</tbody>
</table>

**Abstract**  
Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and devices by a sequence of defined processing steps (process flow).

**Objective**  
Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (→ process flow).

**Content**  
- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.
- Application of selected technologies will be demonstrated on case studies.

**Lecture notes**  
Lecture notes

**Literature**  
- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

**Prerequisites / notice**  
Prerequisites: Physics I and II

### 151-0640-00L  
**Studies on Mechatronics**

<table>
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<tr>
<th>Credit Type</th>
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<th>Semester</th>
<th>Supervisor</th>
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<tbody>
<tr>
<td>W</td>
<td>5</td>
<td>11A</td>
<td>Supervisors</td>
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</table>

**Abstract**  
Overview of Mechatronics topics and study subjects. Identification of minimum 10 pertinent refereed articles or works in the literature in consultation with supervisor or instructor. After 4 weeks, submission of a 2-page proposal outlining the value, state-of-the-art and study plan based on these articles. After feedback on the substance and technical writing by the instructor, project commences.

**Objective**  
The students are familiar with the challenges of the fascinating and interdisciplinary field of Mechatronics and Mikrosystems. They are introduced in the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

**Content**  
The students work independently on a study of selected topics in the field of Mechatronics or Microsystems. They start with a selection of scientific papers to continue literature research. The results (e.g. state-of-the-art, methods) are evaluated with respect to predefined criteria. Then the results are presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.

**Literature**  
will be available

### 151-0703-00L  
**Operational Simulation of Production Lines**

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<th>Credit Type</th>
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<th>Semester</th>
<th>Supervisor</th>
</tr>
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<tbody>
<tr>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>P. Acél, A. Kunz</td>
</tr>
</tbody>
</table>

**Abstract**  
The students learn the application of the event-based and computer-based simulation for layout and improvement of production facilities by means of practical examples and by using the so-called «Digital Twin» within the context of «Industry 4.0». They learn how virtual and mixed reality tools can be used together with the Digital Twin to plan and support the operation of a production line.

**Objective**  
The students learn the correct use of (Who? When? How?) of the event-driven and computer-based simulation in the illustration of the operating procedures and the production facilities. The simulation is an important basis for creating a digital twin in the context of Industry 4.0. Operating simulation in the productions, logistic and scheduling will be shown by means of practical examples.

**Content**  
- Application and application areas of the event-driven simulation
- Simulation in the context of Industry 4.0 (digital twin)
- Exemplary application of a software tool (Technomatrix-Simulation-Software)
- Internal organization and functionality of simulation tools
- Procedure for application: optimizing, experimental design planning, analysis, data preparation
- Controlling philosophies, emergency concepts, production in sequence, line production, rescheduling
- Application on the facilities projecting
- Applications of Virtual and Mixed Reality

**Lecture notes**  
The knowledge is enhanced by practice-oriented exercises and an excursion. A guest speaker will present a practical example.

**Literature**  
A bibliography will be handed out during the lectures.

**Prerequisites / notice**  
Recommended for all Bachelor-Students in the 5th semester and Master-Students in the 7th semester (MAVT, MTEC, PhD students in material sciences) and for all with interest in production (e.g., MTEC, HEST, etc.)
The lecture follows the value added process sequence of electric and electronic components. It contains:

- Development of electric and electronic circuits, design of electronic circuits on printed circuit boards as well as in hybrid technology, integrated test technology, planning of production lines, production of highly integrated electronic on a wafer as well as recycling.
- Value added process steps are shown as well as their quality check and their combination for planning a complete manufacturing line. The lecture further describes the manufacturing of integrated circuits, starting from the wafer via the structuring and bonding to the packaging. As an example, the manufacturing of micro-electromechanic and electro-optical systems and actuators is described. Due to similar processes in the electronic production, the value added process sequence for photovoltaics describes itself.

Nothing works without electronics! Typical products in mechanical engineering such as machine tools, as well as any kind of vehicle contain a significant amount of electronic or electronic components of more than 60%. Thus, it is important to master the value added process sequence for electric and electronic components.

The lecture concludes with an excursion to a large manufacturing company. Here, students can see the application and realization of the manufacturing of electric and electronic devices. It is supplemented by an excursion to one of the industry partners.

The lecture is partly given by experts from industry.

The lecture notes are handed out during the individual lessons.
I- BASICS OF WAVE THEORY
  1) General concepts
  2) Differential wave equation
  3) Wavefront
  4) Plane waves and Fourier decomposition of optical fields
  5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
  1) Maxwell equations
  2) Wave equation for EM waves
  3) Dielectric permittivity
  4) Refractive index
  5) Nonlinear optics
  6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
  1) Waves at an interface
  2) The Fresnel coefficients
  3) Total internal reflection
  4) Evanescent waves
  5) Dispersion diagram

IV- INTERFERENCES
  1) General considerations
  2) Temporal and spatial coherence
  3) The Young double slit experiment
  4) Diffraction gratings
  5) The Michelson interferometer
  6) Multi-wave interference
  7) Antireflecting coating and interference filters
  8) Optical holography

V- LIGHT MANIPULATION
  1) Optical waveguides
  2) Photonic crystals
  3) Metamaterials and metasurfaces
  4) Optical cavities

VI- OPTICAL FORCES AND OPTICAL TWEEZERS
  1) History of optical forces
  2) Theory of optical trapping
  3) Atom cooling
  4) Optomechanics
  5) Applications of optical tweezers

VII- INTRODUCTION TO OPTICAL MICROSCOPY
  1) Basic concepts
  2) Direct and Fourier imaging
  3) Image formation
  4) Fluorescence microscopy
  5) Scattering-based microscopy
  6) Digital holography
  7) Computational imaging

Lecture notes
Class notes and handouts
Literature
Optics (Hecht) - Pearson
Prerequisites / notice
Physics
Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed
assessed
Method-specific Competencies
Analytical Competencies
Problem-solving
assessed
assessed
Personal Competencies
Creative Thinking
Critical Thinking
assessed
assessed

151-0941-00L Molecular Sensors: From Fundamentals to Health and Environmental Applications

Note: previous course title until HS23 "Molecular Health Sensors and Devices"

Abstract
Molecular sensors are used in everyday life in health care, environmental monitoring, food safety, space and other fields. Sources of molecular information, its transport and fundamental concepts of molecular sensing will be discussed. In the scope of group projects, the acquired knowledge will be applied and deepened in case studies.

Objective
After the course, the students will:

- know the requirements and merits of molecular sensors for health, environmental and other emerging applications (e.g. space)
- understand transport phenomena of molecular information & surface interactions and know how to quantitatively describe these
- understand fundamental sensing concepts for the detection and quantification of molecular analytes
- know concepts of signal processing
- be capable to apply the learnt knowledge to conceive and engineer sensor concepts and systems
- know how to investigate sensor-related literature and present scientific data

This course consists of a theoretical and a project-based learning block. In the first 10 semester weeks, theoretical knowledge will be provided through lectures and deepened in corresponding exercises. In the last 4 weeks, the students will apply the learned concepts through group projects to investigate case studies. The outcome will be present.

Content
Transport of Molecular Information; Surface Interactions; Sensor Fundamentals; Chemoresistive Sensing; Electrochemical Sensing; Mass-sensitive; Capacitive Sensing; Signal Processing; Medical Requirements for Molecular Sensing

Lecture notes
Hand-outs will be provided to each lecture including the exercises and their solutions.
Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation fostered
Leadership and Responsibility fostered
Sensitivity to Diversity fostered
Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered

227-0113-00L Power Electronics W 6 credits 4G J. Huber
Abstract
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.
Objective
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.
Content
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DCDC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase AC/DC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.
Lecture notes
Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.
Prerequisites / notice
Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Negotiation fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

227-0124-00L Embedded Systems W 6 credits 4G M. Magno
Abstract
An embedded system is a combination of hardware and software, either fixed in function or programmable, that is designed for a specific application scenario or for a specific task within a larger system. They are part of industrial machines such as agricultural and manufacturing equipment, automotive systems, medical equipment, household appliances, sensor networks, and the Internet of Things.
Understanding the specific requirements and problems that arise in embedded system applications.

Understanding the hardware structure of a microcontroller and an embedded system; memory architecture and memory map, internal and external peripherals, low-power and low-energy design as well as instruction sets and computational accelerators.

Understanding the firmware structure of a microcontroller and an embedded system; low-level instruction set, hardware-software interfaces, communication between components, embedded real-time operating systems, real-time scheduling, shared resources, low-power and low-energy programming as well as computational accelerators.

Using formal models and methods for designing and optimizing embedded systems.

Gaining experience with practical applications of the C programming language, embedded real-time operating systems, and debug functionalities of the associated design environment to design, implement, and verify embedded firmware.

Through project-based activities, students will gain substantial experience in applying the C programming language in the context of embedded systems. Projects will involve developing and implementing firmware, utilizing embedded real-time operating systems, and exploring the debugging functionalities within design environments. This hands-on approach aims to bridge the gap between theoretical knowledge and practical application, allowing students to experience the full lifecycle of embedded system development from design to implementation and verification.

This lecture focuses on the design of embedded systems using formal models and methods.

Besides the theoretical lecture, the course contains laboratory sessions where students transfer the learned theoretical aspects into praxis by programming a microcontroller and interfacing it with sensors and actuators. Students will be exposed to a commercial microcontroller, and the development board extend with a custom-designed embedded system educational platform.

Specifically, the following topics will be covered in the course: hardware and software structures of embedded systems, low-level instruction set, memory architecture and memory map, peripherals, hardware-software interfaces, communication between components, firmware design methodologies, firmware design using the C programming language, embedded real-time operating systems, real-time scheduling, shared resources, low-power, and low-energy designs as well as computational accelerators.

Lecture notes

Lecture material, publications, exercise sheets, and laboratory documentation will be available on the course’s Moodle page.

Literature


Prerequisites / notice

Prerequisites: C programming, circuit theory, digital logic, binary number representations.

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

227-0517-10L Fundamentals of Electric Machines W 6 credits 4G D. Bortis

Objective

The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

Content

- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes

Lecture notes and associated exercises including correct answers

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making fostered

Problem-solving fostered

376-1504-00L Physical Human Robot Interaction (pHRI) W 4 credits 2V+2U O. Lambercy, P. Wolf

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.
The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic package (http://rolmant.aei.orn.ch/teleop/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Will be distributed on Moodle before the lectures.


data: 02.07.2024 12:39

autumn semester 2024

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### Micro- and Nanosystems Technology

**Focus Coordinator:** Prof. Christofer Hierold

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0621-00L</td>
<td>Microsystems I: Process Technology and Integration</td>
<td>W+</td>
<td>6</td>
<td>3V+2U</td>
<td>M. Haluska, C. Hierold</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).</td>
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<tr>
<td>Objective</td>
<td>Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps ( = process flow).</td>
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</tbody>
</table>
| Content      | - Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)  
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.  
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.  
- Application of selected technologies will be demonstrated on case studies. |
| Literature   | Handouts (available online)  
- W. Menz, J. Mohr, O.Paul: Microsystem Technology  
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology  
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications |
| Prerequisites /notice | Prerequisites: Physics I and II |

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<tr>
<th>Number</th>
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<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Ahmed</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotic.</td>
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<td>Objective</td>
<td>The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.</td>
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<tr>
<td>Content</td>
<td>Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices</td>
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<tr>
<td>Prerequisites /notice</td>
<td>Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions ( both compulsory) and hand in homework.</td>
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</table>
| Competencies | Subject-specific Competencies  
- Concepts and Theories  
- Techniques and Technologies  
- Analytical Competencies  
- Decision-making  
- Media and Digital Technologies  
- Problem-solving  
- Project Management  
- Communication  
- Cooperation and Teamwork  
- Customer Orientation  
- Leadership and Responsibility  
- Self-presentation and Social Influence  
- Sensitivity to Diversity  
- Negotiation  
- Critical Thinking  
- Integrity and Work Ethics  
- Self-direction and Self-management |

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<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
<tr>
<td>Abstract</td>
<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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</tbody>
</table>
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Offered In</th>
<th>Supervisor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0643-00L</td>
<td>Studies on Micro and Nano Systems</td>
<td>W</td>
<td>5</td>
<td>11A</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The students get familiarized with the challenges of the fascinating and interdisciplinary field of Micro- and Nanosystems. They are introduced to the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>Students work independently on a study of selected topics in the field of Micro- and Nanosystems. They start with a selection of scientific papers, and continue with an independent literature research. The results (e.g. state-of-the-art, methods) are evaluated with respect to predefined criteria. Then the results are presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.</td>
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<td></td>
<td><strong>Literature</strong></td>
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<td>Literature will be provided</td>
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<tr>
<td>151-0913-00L</td>
<td>Introduction to Photonics</td>
<td>W</td>
<td>4</td>
<td>R. Quidant, J. Ortega Arroyo</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.</td>
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<td><strong>Objective</strong></td>
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<td>Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td>Literature will be provided</td>
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</tbody>
</table>
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel coefficients
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Applications of optical tweezers

VII- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

Lecture notes
Class notes and handouts
Literature
Optics (Hecht) - Pearson
Prerequisites / notice
Physics
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

151-0941-00L Molecular Sensors: From Fundamentals to Health and Environmental Applications
W 4 credits 2V+2U A. Güntner, P. Gerber
Note: previous course title until HS23 "Molecular Health Sensors and Devices"
Abstract
Molecular sensors are used in everyday life in health care, environmental monitoring, food safety, space and other fields. Sources of molecular information, its transport and fundamental concepts of molecular sensing will be discussed. In the scope of group projects, the acquired knowledge will be applied and deepened in case studies.

Objective
After the course, the students will:

• know the requirements and merits of molecular sensors for health, environmental and other emerging applications (e.g. space)
• understand transport phenomena of molecular information & surface interactions and know how to quantitatively describe these
• understand fundamental sensing concepts for the detection and quantification of molecular analytes
• know concepts of signal processing
• be capable to apply the learnt knowledge to conceive and engineer sensor concepts and systems
• know how to investigate sensor-related literature and present scientific data

This course consists of a theoretical and a project-based learning block. In the first 10 semester weeks, theoretical knowledge will be provided through lectures and deepened in corresponding exercises. In the last 4 weeks, the students will apply the learned concepts through group projects to investigate case studies. The outcome will be present.

Content
Transport of Molecular Information; Surface Interactions; Sensor Fundamentals; Chemoresistive Sensing; Electrochemical Sensing; Mass-sensitive; Capacitive Sensing; Signal Processing; Medical Requirements for Molecular Sensing
Lecture notes
Hand-outs will be provided to each lecture including the exercises and their solutions.

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Competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Sensitivity to Diversity: fostered

**Personal Competencies**
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered

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**Additional Case for the Focus Specialization**

*Exclusive for D-MAVT Bachelor's students in Focus Specialization.*

For enrollment, please contact the D-MAVT Student Administration.

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### Solid State Electronics and Optics

**W**  6 credits  4G  N. Yazdani, V. Wood

*Abstract*

"Solid State Electronics" is an introductory condensed matter physics course covering crystal structure, electron models, classification of metals, semiconductors, and insulators, band structure engineering, thermal and electronic transport in solids, magnetoresistance, and optical properties of solids.

*Objective*

Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.

*Prerequisites / notice*

Recommended background: Undergraduate physics, mathematics, semiconductor devices

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### Engineering for Health

*Focus Coordinator: Prof. Bradley Nelson*

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<table>
<thead>
<tr>
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<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Ahmed</td>
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*Abstract*

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

*Objective*

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

*Content*

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

*Lecture notes*


*Literature*


*Prerequisites / notice*

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

The lecture will be taught in English. The lecture slides will be made available as pdf files. Several readings will also be available electronically.

<table>
<thead>
<tr>
<th>Competencies</th>
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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
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<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
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<td>Techniques and Technologies</td>
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<td>Self-presentation and Social</td>
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<td>Influence</td>
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</table>

**Continuum Mechanics I**

**Abstract**

The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

**Objective**

After successful completion of the course students are able to:
- Explain basic theories for solving continuum mechanics problems
- Proficiently apply these theories by solving application-related academic examples
- Relate the theories and examples to real engineering applications and challenges
- Differentiate between different mechanical behaviors of materials
- Systematically select appropriate constitutive theories suitable to analyze and model these materials

**Content**

Anisotropic Elasticity, Linear Elastic and Linear Viscous Material Behavior, Viscelasticity, Micro-Macro Modelling, Laminate Theory, Plasticity, Viscoplasticity, Examples of Engineering Applications, Comparison with Experiments

**Lecture notes**

Yes

**Competencies**

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking

**Microrobotics**

This is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**

The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

**Content**

- Main topics of the course include:
  - Scaling laws at micro/nano scales
  - Electrostatics
  - Electromagnetism
  - Low Reynolds number flows
  - Observation tools
  - Materials and fabrication methods
  - Applications of biomedical microrobots

**Lecture notes**

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

**Prerequisites / notice**

The lecture will be taught in English.

**Microsystems I: Process Technology and Integration**

**Abstract**

Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of micromachined devices by a sequence of defined processing steps (process flow).

**Objective**

Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (= process flow).

**Content**

- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific micromachining technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.
- Application of selected technologies will be demonstrated on case studies.

**Lecture notes**

Handouts (available online)

**Literature**

- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

**Prerequisites / notice**

Prerequisites: Physics I and II

**Studies on Engineering for Health**

The student is responsible to find a project offered and supervised by ETH Professor in the area of Engineering

**151-0524-00L**

**151-0604-00L**

**151-0621-00L**

**151-0621-00L**

**Supervisors**
Overview of Engineering for Health topics. Identification of minimum 10 pertinent refereed articles or works in the literature in consultation.
**Content**
Role of international engineering during colonialism
Transition of international engineering following colonialism
White saviourism and racism in international engineering
International engineering in popular culture
The missing role of Engineering Education
Biases in academic publishing
The emerging role in Global Philanthropy
The paradox of International funding

**Literature**

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<tr>
<td>Personal Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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**227-0385-10L Biomedical Imaging**

**Objective**
Upon completion of the course students are able to:
- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

**Content**
- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

**Literature**
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

**Prerequisites / notice**
Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

**Competencies**

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**227-0393-10L Bioelectronics and Biosensors**

**Abstract**
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectric signals and the basic concepts to record optogenetically modified organisms are introduced.

**Objective**
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectric signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field
Lecture topics:

1. Introduction
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley
5. Measuring bioelectronic signals
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics
10. Functional electric stimulation
11. In vivo electrophysiology
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy
14. Measuring biochemical signals

Competencies

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376-0021-00L Materials and Mechanics in Medicine

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes course website on Moodle

Literature

376-0203-00L Movement and Sport Biomechanics

Abstract
Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

Objective
Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics.

Content
Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

Lecture notes Is available within the Moodle

Competencies

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376-1504-00L Physical Human Robot Interaction (pHRI)

Abstract

Objective

Content

Lecture notes

Competencies

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Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1761 of 2667
Abstract
This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

Objective
The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Content
This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

The students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html!), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes
Will be distributed on Moodle before the lectures.

Literature

Prerequisites / notice
Notice:
The registration is limited to 26 students.
There are 4 credit points for this lecture.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes. http://www.relab.ethz.ch/education/courses/phri.html
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

Biocompatible Materials

**Abstract**
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.
A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**
Handouts are deposited online (moodle).

**Literature**

(available online via ETH library)

Handouts and references therein.

**Design, Mechanics and Manufacturing**

*Focus Coordinator: Prof. Dennis Kochmann*

To achieve the required 20 credit points for the Focus Specialization Design, Mechanics and Manufacturing, all of the courses listed can be selected. If you wish to take a Master level course, you must obtain the consent of the responsible lecturer. After approval by the focus coordinator, an additional course to the listed courses can be requested. There are recommended lectures for the "Design" track, the "Mechanics" track and the "Manufacturing" track. For recommended courses and further information, please visit the MAVT website for Focus Specialization ([https://mavt.ethz.ch/studies/bachelor/focus/focus-specialization.html](https://mavt.ethz.ch/studies/bachelor/focus/focus-specialization.html)).

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<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0364-00L</td>
<td>Lightweight Structures Laboratory</td>
<td>W</td>
<td>4 credits</td>
<td>5A</td>
<td>M. Zogg</td>
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</table>

**Abstract**
Teams of 2 to 3 students have to design, size, and manufacture a lightweight structure complying with given specifications. An aircraft wing spar prototype as well as later a second improved spar will be tested and assessed regarding to design and to structural mechanical criteria.

**Objective**
To develop the skills to identify and solve typical problems of the structure mechanics on a real application. Other important aspects are to foster team work and team spirit, to link theoretical knowledge and practice, to gather practical experiences in various fields related to lightweight structures such as design, different CAE-methods and structural testing.

**Content**
The task of each team (typically 2-3 students) is the realization of a reduced-scale aircraft wing spar, a typical load-carrying structure, with selected materials. The teams are free to develop and implement their own ideas. In this context, specified requirements include information about loads, interface to the surrounding structures.

The project is structured as described below:
- Concept development
- design of the component including FEM simulation and stability checks
- manufacturing and structural testing of a prototype in the lab
- manufacturing and structural testing of an improved component in the lab
- cost assessment
- Report

The practical project work is supported by selected teaching units.

**Lecture notes**
handouts for selected topics are available
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices.


Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

After successful completion of the course students are able to
• explain basic theories for solving continuum mechanics problems
• proficiently apply these theories by solving application-related academic examples
• relate the theories and examples to real engineering applications and challenges
• distinguish between different mechanical behaviors of materials
• systematically select appropriate constitutive theories suitable to analyze and model these materials

Anisotropic Elasticity, Linear Elastic and Linear Viscoelastic Material Behavior, Viscoelasticity, Micro-Macro Modelling, Laminate Theory, Plasticity, Viscoplasticity, Examples of Engineering Applications, Comparison with Experiments

Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.
Content

(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincaré maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

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<th>Code</th>
<th>Course Title</th>
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<th>Module Type</th>
<th>Tutor</th>
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<td>151-0544-00L</td>
<td>Metal Additive Manufacturing - Mechanical Integrity and Process Simulation</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>E. Hosseini</td>
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<td>Note: The previous course title until HS22 “Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis”</td>
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<tr>
<td>Abstract</td>
<td>An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.</td>
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<td>Objective</td>
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<td>- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),</td>
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<td>- Understanding the importance of material science and metallurgical considerations in MAM,</td>
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<td>- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,</td>
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<td>- Using commercial analysis tools (e.g. ABAQUS) for simulation of the MAM process.</td>
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<td>Content</td>
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<td>- Introduction to MAM (concept, application examples, pros &amp; cons),</td>
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<td>- Powder-bed and powder-blown metal additive manufacturing,</td>
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<td>- Thermo-fluid analysis of additive manufacturing,</td>
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<td>- Continuum-based thermal modelling and experimental validation techniques,</td>
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<td>- Residual stress and distortion simulation and verification methods,</td>
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<td>- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),</td>
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<td>- Mechanical property prediction for MAM,</td>
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<td>- Microstructure and mechanical response of MAM material (stainless steel, Ti6Al4V, Inconel 718),</td>
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<td></td>
<td>- Design for additive manufacturing</td>
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<td>- Artificial intelligence for AM</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts of the presented slides.</td>
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<tr>
<td>Literature</td>
<td>No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).</td>
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<td>Prerequisites / notice</td>
<td>A basic knowledge of mechanical analysis, metallurgy, thermodynamics is recommended.</td>
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Competencies

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- Techniques and Technologies

Method-specific Competencies
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- Problem-solving
- Project Management

Social Competencies
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Personal Competencies
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- Critical Thinking

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<td>151-0720-00L</td>
<td>Production Machines I</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>M. Bambach</td>
<td></td>
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<tr>
<td></td>
<td>First part of the lecture on production machines. Introduction to the special features of production machines on the basis of metal cutting and forming machine tools. Dimensioning and design, as well as specific functional components.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Elaboration of the special requirements on the machine tools, such as precision, dynamics, long-life and their realisation. Development and respectively assorted of the most important components.</td>
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<tr>
<td>Objective</td>
<td>Basics of the machine tool design, Six-point principal is shown. Components of machine tools (foundations, frames, bearings, guides, measuring systems, drives and their control) and their types of machine designs. Terminology, classification and quality characteristics. Special components and selected types of forming machines and there design and dimensioning. Insight into safety of machinery and automation.</td>
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<tr>
<td>Lecture notes</td>
<td>yes</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Contact</th>
<th>Credit</th>
<th>Module Type</th>
<th>Tutor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0741-00L</td>
<td>Sustainable Materials</td>
<td>W</td>
<td>4</td>
<td>2V+2A</td>
<td>L. Deillon</td>
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<tr>
<td></td>
<td>The lecture addresses the issue of sustainability in manufacturing, focussing on materials. The most used materials, their production and transformation into a product are analysed in terms of energy consumption and emissions. Emphasis is then placed on alternative design strategies which reduce the use of materials and innovative processes which lower energy consumption and emissions.</td>
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<tr>
<td>Abstract</td>
<td>After this lecture students will be able to:</td>
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<td></td>
<td>- Develop a critical thinking of published sustainability data and facts</td>
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<td></td>
<td>- Explain where the materials that we use come from, what emissions arise from the different steps of raw material production and product manufacturing</td>
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<td>- Determine where significant changes can be brought</td>
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<td></td>
<td>- Develop feasible solutions towards a more sustainable use of materials</td>
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</tbody>
</table>
Content
- Introduction: what is sustainability, which industrial sectors are responsible for the most CO2 (and other) emissions
- The "real" numbers: where to find reliable data and how one can play with the figures
- Basics of life cycle analysis
- CO2 and other emissions
- The most used materials
  - The 5 most used materials today, their key properties and what they are used for
  - Evolution of production, consumption and resources
- Production, recyclability and new processing routes for Al and steel
- Use less material by design
- Re-use of materials & prolonging products life
- Production of cement, new developments & alternatives
- Presentation of students' projects

Lecture notes
- Slides distributed and available on Moodle

Literature
- References given in the lecture

151-0763-00L  
**Practical Course of CAD and CAE Application in Projects**  
*Note: Previous course title until HS23 "Practice Course to Focus Projects on CAD and CAE Based on Siemens NX"*

**Abstract**
This course provides comprehensive input to ongoing Focus Projects teams in the areas of CAD and CAE mit Siemens NX.

**Objective**
Participants will receive tips, hints and background information from experienced tutors applicable to current projects.

**Content**
- CAD with Siemens NX
  - 2 day of intensive training (2x4h, 1x8L)
- CAE mit Siemens NX
  - 2 separate days of intensive training (2x8L)

**Lecture notes**
Lecture notes and documentation will be electronically available.

151-0833-00L  
**Applied Finite Element Analysis**

**Abstract**
Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

**Objective**
The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:
- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

**Content**
- introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

**Lecture notes**
Lecture slides

**Literature**

151-3204-00L  
**Coaching Innovation Projects**

**Abstract**
The course is building up skills and experience in coaching engineering teams. To gain experience and to reflect real coaching situations, the participants of the course have the role of teaching assistance of the innovation project (151-0300-00L). In this framework the participants coach teams and professionalize the knowledge in the area product development methods.

**Objective**
- Critical thinking and reasoned judgements
- Basic knowledge about role and mindset of a coach
- Understanding the challenges of engineering projects and design teams
- Development of personal skills to apply and train product development methods
- Knowledge and know-how about applying methods
- Reflection and exchange of experiences about personal coaching situations
- Inspiration and learning from good cases regarding organizational and team management aspects
- Decision-making under uncertainty
Content
the following topics will be covered in the lecture:
- Kick-off & Experience Exchange
- Coaching Role
- Active Listening
- Giving and Receiving Feedback
- Team Building & Psychological Safety
- Building Hypotheses in the coaching process
- conflict resolution and motivation

In addition to the content topics, one-on-one coaching will be provided and classes will reflect on current, practical issues derived from coaching of the innovation teams.

Prerequisites / notice
Only for participants (Bachelor Students, Master Students) who are teaching assistants in the innovation project).

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<tr>
<td>fostered</td>
<td>assessed</td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
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</tbody>
</table>

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed

Personal Competencies

Adaptability and Flexibility assessed
Critical Thinking assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

Lecture notes

Handouts, Exercises available on Moodle

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Lecture notes

Handouts, Exercises available on Moodle

Abstract

The elective course Lightweight includes numerical methods for the analysis of the load carrying and failure behavior of lightweight structures, as well as construction methods and design principles for lightweight design.

Objective

The goal of this course is to convey substantiated background for the understanding and the design and sizing of modern lightweight structures in mechanical engineering, vehicle and airplane design.

Content

Lightweight design
Thin-walled beams and structures
Instability behavior of thin walled structures
Reinforced shell structures
Load introduction in lightweight structures
Joining technology
Sandwich design

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Lecture notes

Handouts, Exercises

Abstract

The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them.

Objective

The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.

Content

1. Optimization modeling and theory
2. Unconstrained optimization methods
3. Constrained optimization methods
4. Direct search methods
5. Stochastic and evolutionary search methods
6. Multi-objective optimization

Lecture notes

Handouts, Exercises available on Moodle

Abstract

This course introduces students to engineering design and fabrication by building their own skis or snowboard. Theoretical and applied engineering design skills like CAD, analysis and engineering of mechanical properties, 3D printing, laser cutting and practical handcrafting skills are acquired in the course.

Objective

The objectives of the course are to use the practical ski/board design and building exercise to gain hands-on experience in design, mechanics and materials. A selection of sustainable materials are also used to introduce students to sustainable design. The built skis/board will be mechanically tested in the lab as well as together out in the field on a ski day and evaluated from various perspectives. Students can keep their personal built skis/boards after the course.

Content

This practical ski/board design and building workshop consists of planning, designing, engineering and building your own alpine ski or snowboard. Students learn and execute all the needed steps in the process, such as engineering design, CAD, material selection, analysis of the mechanical properties of a composite layup, fabrication, routing wood cores, 3D printing of plastic protectors, milling side walls from wood or ABS plastic, laying up the fibers from carbon, glas, basalt or flax, laminating with resins, sanding and finishing, as well as laser engraving and veneer wood inlays.

Lecture notes

Handouts, Exercises

Prerequisites / notice

Willingness to engage in the practical building of your ski/board also beyond the course hours in the evening.

Bachelor's Thesis
### Bachelor Studies (Programme Regulations 2010)

#### Electives

**Engineering Tools**

*The Engineering Tools courses are for MAVT Bachelor's degree students only.*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0059-10L</td>
<td>Engineering Tool: CAD-Methodology and PDM-Technology in the Focus Project</td>
<td>W</td>
<td>0.4</td>
<td>1K</td>
<td>M. Schütz</td>
</tr>
</tbody>
</table>

**Abstract**

The participants learn about the procedures and tools that are necessary to develop technical products. The focus is on computer-based design and development and the management in an integrated software environment.

**Objective**

The participants will deepen their existing CAD knowledge and learn new PDM knowledge, so that these may be directly applied and used in the focus project.

- CAD refresh (Modelling, Assembling, Drafting, etc.) and CAD mythology for construction (Top-Down modelling)
- TeamCenter data flow, in particular the process of creating and managing new Items and Parts, the approval procedure and creating different versions of Parts
- To refresh already existing knowledge of CAD functionality.
  - Sketch and features as well as manipulation and optimizing models.
  - Assembling
  - Drafting.
  - Organisation, working methods, conventions.
- To top down modelling
  - Introduction to top down modelling and concept modelling
  - Case study of top down modelling

**Content**

1. Afternoon: CAD refresher and top down modelling
   - To refresh already existing knowledge of CAD functionality.
   - Sketch and features as well as manipulation and optimizing models.
   - Assembling
   - Drafting.
   - Organisation, working methods, conventions.
2. Afternoon: Introduction to TC (Team Center)
   - Introduction: Short introduction to PLM (What is the idea of PLM? PLM is more than the pure management of drawings!).
   - Lesson 1 - Team Center Rich Client Interface
   - Lesson 2 - TC data types
   - Lesson 3 - Construction from data in TC
   - Lesson 4 - Searching for and examining data.
3. Afternoon: TC application
   - Lesson 5 - Unit lists (PSE)
   - Lesson 6 - Cross-referencing
   - Lesson 7 - Data release
   - Lesson 8 - Product data examination

**Prerequisites / notice**

- at least two students of a Focus-Team should sign in for this course, if the use of Siemens Teamcenter PLM is given for the Team.
- only for students participating in a Focus Project in the same semester
The main objective is to provide Bachelor's students with practical experience in producing components as well as knowledge and understanding about materials and their machining and finishing. Lecturers

Engineering Tool: Design Optimization and CAD

Objective
By looking at specific examples during class you will obtain an overview on composing scientific papers (e.g. bachelor theses, semester theses, master theses) using LaTeX and acquire the most important commands to typeset complex formulas, tables and graphics.

Content
– layout of scientific reports
– writing with LaTeX (structure, formatting, formulas, tables, graphics, references, table of contents, hyperlinks, packages) based on a template for bachelor/semester/master theses.
– graphic design and illustration using open source software and Matlab
– including PDF files in the report (project description, data sheets)
– managing bibliography databases

Literature
http://www.relab.ethz.ch/education/courses/engineering-tools-latex.html

Prerequisites / notice
The exercises will be done on your personal laptop (at least one laptop per two students). The complete (full) LaTeX package, Inkscape and Gimp should be installed in advance.

151-0062-10L Engineering Tool: Computer-Aided Design Methods W 0.4 credits 1K T. Stankovic, K. Shea

Objective
Participants will learn about the Computer-Aided Design fundamentals and methods that are necessary to model complex technical products. The focus will be placed on feature-based and parametric modelling that is common to all modern CAD tools used in mechanical engineering design.

Content
1. CAD Methods and Feature-Based Design (2 afternoons):
   * CAD in the context of the design process
   * Feature types and their relation to mechanical design
   * Strategies for building feature-based assemblies
   * Integration of digital part libraries
   * Common issues and difficulties with feature interaction

2. CAD and Parametric Modeling (1 afternoon):
   * Designing and building parametric models
   * Design automation to create design variants
   * Common issues and difficulties with parametric modeling
   * Introduction to Finite-Element Method (FEM) with basic examples
   * Simulation-driven design
   * CAE in the context of the design process
   * Integration of digital part libraries
   * Common issues and difficulties with feature interaction
   * CAD in the context of the design process
   * Feature types and their relation to mechanical design
   * Strategies for building feature-based assemblies
   * Introduction to design optimization
   * Features, parameterization and synchronous modeling technology
   * Basic design optimization examples
   * Introduction to Finite-Element Method (FEM) with basic examples

Lecture notes
available on Moodle

151-0069-10L Engineering Tool: Design Optimization and CAD W 0.4 credits 1K T. Stankovic

Objective
Participants will learn about the Computer-Aided Engineering fundamentals and methods that are necessary for successful design of modern technical products. The focus will be placed on the simulation-driven design in the context of product development process as well as on the fundamentals of the design optimization.

Content
1. Computer-Aided Engineering (CAE) methods and tools in context of design process (2 afternoons):
   * CAE in the context of the design process
   * Simulation-driven design
   * Introduction to design optimization
   * Features, parameterization and synchronous modeling technology
   * Basic design optimization examples
   * Introduction to Finite-Element Method (FEM) with basic examples

2. Simulation-Driven Design with application to structural design (1 afternoon):
   * Coupling simulation with structural design optimization and feature-based design
   * Simulation driven design examples (single parts and assemblies)

Lecture notes
Handouts in the lecture

Literature
1. CAD NX:
   2. CAE NX:

Prerequisites / notice
Max. 25 participants

Workshop Training

Number Title Type ECTS Hours Lecturers
151-0003-00L Workshop Training Placement of internships and request for recognition under www.mavt.ethz.ch/praxis O 5 credits external organisers

Abstract
The main objective of the minimum five-week internship is to provide Bachelor’s students with practical experience in producing components as well as knowledge and understanding about materials and their machining and finishing.

Objective
The main objective is to provide Bachelor’s students with practical experience in producing components as well as knowledge and understanding about materials and their machining and finishing.
The minimum duration of the workshop training is five weeks.

**Laboratory Practice**

Students attend at least 10 Laboratory Practices during the 4th and 5th semester. 4 of them must be Physics laboratories. All laboratory works are graded "pass" or "fail". After completion of 10 laboratory training units, 2 credit points will be issued.

Please register online at www.mavt.ethz.ch/praktika

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0029-10L</td>
<td>Laboratory Practice</td>
<td>O</td>
<td>2 credits</td>
<td>4P</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract

Selected laboratory experiments in physics, mechanical and process engineering. With the Laboratory Training held during the fourth and fifth semester, the students learn how to handle and apply measurement methods and devices. Students are offered a diversified choice of laboratory experiments at least ten of which must be completed. Four of the chosen experiments must be in physics.

Objective

With the Laboratory Training held during the fourth and fifth semester, the students learn how to handle and apply measurement methods and devices.

Prerequisites / notice

Der Link zur Website, welche alle Informationen für das Physikpraktikum bietet: https://ap.phys.ethz.ch

**Bachelor's Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0001-10L</td>
<td>Bachelor's Thesis</td>
<td>W</td>
<td>14 credits</td>
<td>30D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract

The Bachelor's Thesis is the culmination of the program. The thesis corresponds to a work load of 420 hours and can be done in part- or full-time.

Objective

The students develop, enhance and demonstrate their methodological abilities to independently tackle and solve a given research problem.

Content

The topics for the bachelor's thesis are published by the professorship or they can be set in consultation between the professors and the students. Thesis projects in cooperation with the industry are also possible.

Prerequisites / notice

The Bachelor's Thesis can be only started when the First Year Examinations, the Additional First Year Courses, the Examination Block 1 and 2 are passed. It is insistently recommended for students to only begin the Bachelor's Thesis if 150 credit points have been achieved.

The declaration of originality is an integral part of the Bachelor's Thesis

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-3630-00L</td>
<td>Bachelor's Thesis (Focus Specialization Management, Technology and Economics)</td>
<td>W</td>
<td>14 credits</td>
<td>30D</td>
<td>Professors</td>
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</tbody>
</table>

Abstract

The Bachelor's Thesis is the culmination of the program. The thesis corresponds to a work load of 420 hours and can be done in part- or full-time.

Objective

The students develop, enhance and demonstrate their methodological abilities to independently tackle and solve a given research problem.

Content

The topics for the bachelor's thesis are defined by the professorship or can be set in consultation between the professors and the students.

Prerequisites / notice

The Bachelor's Thesis can be only started when the First Year Examinations, the Additional First Year Courses, the Examination Block 1 and 2 are passed. Exclusively D-MAVT students who have enrolled for the Focus Specialization Management, Technology and Economy are eligible for this type of Bachelor's Thesis.

It is strongly recommended for students to only begin the Bachelor's Thesis if 150 credit points have been achieved.

The declaration of originality is an integral part of the Bachelor's Thesis

**Science in Perspective**

**Language Courses**

**Mechanical Engineering Bachelor - Key for Type**

| O   | Compulsory                            | E-   | Recommended, not eligible for credits |
| W+  | Eligible for credits and recommended  | Z    | Courses outside the curriculum       |
| W   | Eligible for credits                  | Dr   | Suitable for doctorate               |
### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course/private study</td>
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**ECTS**  
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0105-00L</td>
<td>Imaging in Fluid Dynamics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>F. Coletti</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This is a laboratory-based course on imaging</td>
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<td>techniques for the measurement of fluid</td>
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<td>flow properties. Modern approaches are</td>
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<td>presented, including particle image</td>
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<td>velocimetry and particle tracking</td>
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<td>velocimetry, applied in various experimental</td>
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<td>facilities. Students obtain first-hand</td>
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<td>experience with such techniques in</td>
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<td>laboratory sessions, using high-speed/</td>
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<td>high-resolution cameras in wind/water</td>
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<td>tunnels.</td>
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<td><strong>Objective</strong></td>
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<td>Knowledge of the working principles of</td>
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<td>modern flow imaging and velocimetry.</td>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Conception of laboratory experiment to be</td>
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<td>characterized by imaging, with focus on the</td>
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<td>S.B. Pope, Turbulent Flows, Cambridge</td>
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<td>2. Identify and predict the onset of</td>
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<td>3. Describe acoustic wave behaviour in</td>
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<td>4. Explain tension, nucleation and phase-</td>
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<td>5. Predict the behaviour of a gas bubble</td>
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151-0163-00L Nuclear Energy Conversion

**Abstract**
Physical fundamentals of the fission reaction and the sustainable chain reaction, thermodynamic, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding.

**Objective**
Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.

**Content**
Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of reactor technology.

**Lecture notes**
Hand-outs will be distributed. Additional literature and information on the website of the lab: https://www.ethz.ch/content/specialinterest/mavt/energy-technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00l-nuclear-energy-conversion.html

**Literature**

R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

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151-0204-00L Aerospace Propulsion

**Abstract**
An introduction of working principals and design of airbreathing engines as well as rocket propulsion are presented. Key elements of the propulsion system as well as the design choices for the engineering of various components are examined.

**Objective**
Introduction of working principals and design of aircraft engines and the related background in aero- and thermodynamics. Engineering aspects of the component designs are examined.

**Content**
This course focuses on the fundamental concepts as well as the applied technologies for aerospace application, with a primary focus related to aviation. The systematic evolution of the aircraft propulsion engines, from turbojet to the modern high bypass ratio turbofan, including the operational limitations, are examined. Following the system analysis, the aero/thermo design of each component, including the inlet, fan, compressor, combustors, turbines and exhaust nozzles are presented. The mechanical and material limitations, as well as design choices related to manufacturing and operability of engines are also presented. The environmental aspects of propulsion (noise and emissions) are also presented. In the last part of the course, a basic introduction to the fundamentals of space propulsion is also presented.

**Lecture notes**
Lecture notes will be distributed. There will be NO recording of the lectures, nor the exercise sessions. Physical attendance in this course is advised.

**Literature**
Aircraft Engines and Gas Turbines, second edition
By Jack L. Kerrebrock

**Prerequisites / notice**
This course requires prior background in mechanical or aerospace engineering. Students must have already completed courses in basics of Thermodynamics (including cycles) as well as compressible Fluid Dynamics.

**Competencies**

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151-0209-00L Renewable Energy Technologies

**Abstract**
The first part of the course covers the engineering aspects of the prominent renewable energy technologies: solar (PV and thermal), wind, hydro, geothermal and bioenergy. We further discuss energy storage, renewable transport and renewable heating & cooling. Finally, we introduce the key concepts of the economics of renewable energy and its integration in the energy system.

**Objective**
Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

**Lecture notes**
Lecture Notes containing copies of the presented slides.

**Prerequisites / notice**
This course requires strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

**Competencies**

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151-0213-00L Fluid Dynamics with the Lattice Boltzmann Method

**Abstract**
The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.
Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.

The course builds upon three parts:

1. **Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.**
2. **Theoretical basis of statistical mechanics and kinetic equations.**
3. **Lattice Boltzmann method for real-world applications.**

The content of the course includes:

1. **Background:** Elements of statistical mechanics and kinetic theory:
   - Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory; Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation; kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.
2. **Basics of the Lattice Boltzmann Method and Simulations:**
   - Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.
3. **Hands on:**
   - Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).
4. **Practical issues of LBM for fluid dynamics simulations:**
   - Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.
5. **Microflow:**
   - Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.
6. **Advanced lattice Boltzmann methods:**
   - Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.
7. **Introduction to LB models beyond hydrodynamics:**
   - Relativistic fluid dynamics; flows with phase transitions.

Lecture notes and Prerequisites / notice

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<tr>
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<td>Fundamentals of Acoustics</td>
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<td>N. Noiray, B. Van Damme</td>
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<td>151-0216-00L</td>
<td>Wind Energy</td>
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<td>151-0221-00L</td>
<td>Introduction to Modeling and Optimization of Sustainable Energy Systems</td>
<td>4</td>
<td>W</td>
<td>G. Sansavini, A. Bardow, S. Moret</td>
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Abstracts

**Fundamentals of Acoustics**

This course provides an introduction to acoustics. It focuses on fundamental phenomena of airborne and structure-borne sound waves. The lecture combines theoretical principles with practical insights and interpretations.

**Wind Energy**

The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy. These subjects are introduced through a discussion of the basic principles of wind energy generation and conversion, and a detailed description of the broad range of relevant technical, economic and environmental topics.

**Introduction to Modeling and Optimization of Sustainable Energy Systems**

This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.
At the end of this course, students will be able to:
- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

In the course "Introduction to Modeling and Optimization of Sustainable Energy Systems", the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

The global energy transition; Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.

Lecture notes
Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

151-0225-00L Material Characterization by X-ray Techniques: Diffraction, Absorption, Total Scattering
Objective
- Explain the system-level interdependencies/interconnections within the energy system
- Discuss and debate the pros and cons of different ESA models/approaches (for specific applications)

Content
- Analytical Energy Assessment (LCA, 3 units), bottom-up linear optimisation models (5 units) and Multi-Criteria Decision Analysis (MCDA, 3 units).

Abstract
The determination of structure–property relationships in functional materials relies critically on structural characterization methods. This course introduces the basics of X-ray powder diffraction, pair distribution function (PDF) of X-ray total scattering and X-ray absorption spectroscopy analyses to determine the structure of inorganic functional materials.

Content
- Overview of the different characterization methods to investigate the structure of functional materials, spanning the local to long-range order structure.
- X-ray powder diffraction.
- X-ray total scattering and pair distribution function analysis.
- X-ray absorption spectroscopy.
- Practical sessions on X-ray powder diffraction and PDF experiments.

Literature
Literature will be given during the course.

151-0227-00L Basics of Air Transport (Aviation I)
Objective
- The course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

Content
- The program is taught in English and we provide 11 different experts/lecturers.
- The goal is to understand and explain basics, principles and contexts of the broader air transport industry.
- Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport.

Abstract
In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation.

Content
- Preparation visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

Literature
Literature will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)

Prerequisites / notice
The lecture is planned as class teaching.

Competencies
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Communication assessed
- Personal Competencies: Adaptability and Flexibility assessed

151-0245-00L Energy Systems Analysis: an Introduction and Overview with Applications
Objective
- Analyse energy technologies with respect to different criteria/characteristics
- Discuss and debate the pros and cons of different ESA models/approaches (for specific applications)
- Explain the system-level interdependencies/interconnections within the energy system
- Evaluate the effect of uncertainties and "the human dimension" on ESA and scenarios

Abstract
Introductory (advanced Bachelor or beginner Master level) course on Energy Systems Analysis, providing an overview of the field and methods. After an introduction to systems thinking and characterisation of technologies, three main blocks cover with Lifecycle Assessment (LCA, 3 units), bottom-up linear optimisation models (5 units) and Multi-Criteria Decision Analysis (MCDA, 3 units).

Content
- Programme is taught in English and we provide 11 different experts/lecturers.
- The program is taught in English and we provide 11 different experts/lecturers.
- Preparation materials & slides are provided prior to each class

Competencies
- Concept: this course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

Literature
- Preparing materials & slides are provided prior to each class
- Literature will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)
- The lecture is planned as class teaching.
This lecture aims at introducing the students to the working principles and efficiency optimization methods for Internal Combustion (IC) engines which are expected to continue to play a very important role in transportation (long-haul heavy duty, marine) and decentralized combined heat and power generation. Following an overview of different applications and powertrains, the course will focus on the following topics: First, a generic overview of the history of IC-Engines is given, and the basic dimensions and specific engine-relevant terminology are introduced. Next, operating maps for different duty cycles are discussed, highlighting the benefits of individual powertrain configurations for different usage scenarios. The high-pressure thermodynamic process and combustion-induced heat release are analyzed in detail and the design of the combustion processes is discussed in view of further optimization of the energy conversion efficiency. The concept of boosting, its challenges and potential are also presented. In addition, flow field characteristics, convective and radiative heat transfer and combustion modes, boosting and simulation methods, Hybrid powertrains, decentralized power/heat cogeneration and use of renewable/e-fuels.

151-0251-00L Principles, Efficiency Optimization and Future Applications of IC Engines

W 4 credits 2V+1U Y. Wright, P. Soltic

Abstract

Objective
The students get familiar with operating characteristics and efficiency maximization methods of IC engines for propulsion and decentralized electricity (and heat) generation. To this end, they learn about simulation methods and related experimental techniques for performance assessment in a combination of lectures and exercises.

Content
This lecture aims at introducing the students to the working principles and efficiency optimization methods for Internal Combustion (IC) engines which are expected to continue to play a very important role in transportation (long-haul heavy duty, marine) and decentralized combined heat and power generation. Following an overview of different applications and powertrains, the course will focus on the following topics: First, a generic overview of the history of IC-Engines is given, and the basic dimensions and specific engine-relevant terminology are introduced. Next, operating maps for different duty cycles are discussed, highlighting the benefits of individual powertrain configurations for different usage scenarios. The high-pressure thermodynamic process and combustion-induced heat release are analyzed in detail and the design of the combustion processes is discussed in view of further optimization of the energy conversion efficiency. The concept of boosting, its challenges and potential are also presented. In addition, flow field characteristics, convective and radiative heat transfer and combustion modes (Otto, Diesel and “multi-mode” cycles) will be discussed along with possible simulation methods. The course consists of lectures combined with exercises. In addition, several invited guest talks will be held by representatives from Swiss industrial companies active in this field. Provided the pandemic measures allow, visits to different engine test facilities are further envisioned.

151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

W 4 credits 3G A. Kunz

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems. The goal of the lecture is to provide a deeper knowledge of today’s VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality.

Didactical concept:
The course consists of lectures and exercises.

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Problem-solving

Social Competencies

Communication

Cooperation and Teamwork

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Method-specific Competencies

Analytical Competencies

Media and Digital Technologies

Cooperation and Teamwork

Creative Thinking

Critical Thinking

Prerequisites / notice
"Visualization, Simulation and Interaction - Virtual Reality I" is recommended, but not mandatory.
Hands-on Self-Driving Cars with Duckietown

Objective

This course is a hands-on introduction to self-driving cars using the Duckietown platform.

Each student is given a mobile wheeled robot and throughout the class must configure and program.

The objective of the course is to give the student a pragmatic view of what it takes to design and operate a fleet of self-driving cars or any other large robotic systems.

Content

Perception, planning, modeling, and control, leveraging primarily on vision data.

Lecture notes

Lecture notes, primarily in the form of slides and tutorials, will be accessible from Moodle.

Course notes and other education material will be provided for free in an electronic form.

It’s advised students will have ~5 square meters of free space at their place to work with their assigned robot.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

Planning and Decision Making for Autonomous Robots

Planning safe and efficient motions for robots in complex environments, often shared with humans and other robots, is a difficult problem combining discrete and continuous mathematics, as well as probabilistic, game-theoretic, and ethical/regulatory aspects. This course will cover the algorithmic foundations of motion planning, with an eye to real-world implementation issues.

Abstract

The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments.

Objective


Lecture notes

Course notes and other education material will be provided for free in an electronic form.

There is no required textbook, but an excellent reference is Steve Lavalie’s book on “Planning Algorithms.”

Literature

There are several good books on planning that would be appropriate for this course.

Prerequisites / notice

Students should have taken basic courses in optimization, control systems, probability theory, and should be familiar with modern programming languages and practices (e.g., Python, and/or C/C++). Previous exposure to robotic systems is a definite advantage.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Decision-making
- Problem-solving

Mechanics of Composite Materials

The courses treats aspects related to elastic behavior of unidirectional and multidirectional laminates, micromechanics, failure and damage analysis, analysis and design of composite structures. The focus is on laminated fiber-reinforced polymer composites.

Abstract

The objective is to introduce the basic concept of composite materials and provide a thorough understanding of the mechanical response of such materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

Objective

The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics & Homogenization
- Classical Laminate Theory (CLT)
- Strength, failure and damage analysis
- Thin ply composite shells & effects of material non-linearity
- Analysis and design of composite structures

Lecture notes

Script, handouts, exercises and additional material are available in PDF-format on the moodle page of the lecture.

Literature

The lecture material is covered by a script/lecture notes compiled by CMASLab and further literature is referenced therein.
151-0368-00L  
**Aeroelasticity**  
**W** 4 credits  **2V+1U**  
M. Righi

### Abstract
Introduction to the basics and into the methods of Aeroelasticity. An overview of the main static and dynamic phenomena arising from the interaction between structural and aerodynamic loads.

### Objective
The course will provide a basic physical understanding of flow-structure interaction focused on lifting bodies such as wings. You will get to know the most important phenomena in the static and dynamic aeroelasticity, as well as a presentation of the most relevant analytical and numerical prediction methods.

### Content
- Introduction to steady and unsteady thin airfoil theory, extension to three dimension wing aerodynamics, strip theory, overview of numerical methods available (panel methods, CFD).
- Introduction to unsteady aerodynamics (theory): Theodorsen and Wagner functions. Unsteady aerodynamics observed from numerical experiments (CFD). Generation of simplified mathematical models.
- Presentation of steady aeroelasticity: equations of equilibrium for the typical section, aeroelastic deformation, effectiveness of the aeroelastic system, stability (definition), divergence condition, role played by a control surface, control effectiveness, sweep angle, aeroelastic tailoring of bending-torsion coupling. Ritz model to model beams, use of FEM, modal condensation, choice of generalized coordinates.
- Numerical aeroelasticity (Test Cases extracted from the latest AIAA Aeroelastic Prediction Workshops). Generation of Reduced Order Models from CFD data (in some cases though Machine Learning).
- Aeroelasticity of modern aircraft: assessment of the effects induced by the control surfaces and control systems (Aeroservoelasticity), active controlled aircraft, flutter-suppression systems, certification (EASA, FAA).
- Planning and execution of Wind Tunnel experiments with aeroelastic models. Live-execution of an experiment in the WT of the ETH.
- Brief presentation of phenomena like Limit-Cycle Oscillations (LCO) and panel flutter.

### Lecture notes
A script in English language is available.

### Literature
- Bispilnghoff Ashley, Aeroelasticity
- Abbott, Theory of Wing sections,

### Competencies

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151-0371-00L  
**Advanced Model Predictive Control**  
**W** 4 credits  **2V+1U**  
M. Zeilinger, A. Carron, L. Hewing, J. Köhler

### Abstract
Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

### Objective
Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

### Content
- Topics include:
  - Nominal MPC for uncertain systems (nominal robustness)
  - Robust MPC
  - Stochastic MPC
  - Review of regression methods
  - Set-membership Identification and robust data-driven MPC
  - Bayesian regression and stochastic data-driven MPC
  - MPC as safety filter for reinforcement learning

### Lecture notes
Lecture notes will be provided.
Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control in Spring Semester) strongly recommended. Background in linear algebra and stochastic systems recommended.

Prerequisites / notice

151-0409-00L Multiphysics Modeling and Simulation

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Abstract
This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

Objective
As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling. Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

Content
- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

Lecture notes
Lecture handouts will be posted online.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

151-0509-00L Acoustics in Fluid Media: From Robotics to Additive Manufacturing

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<td>D. Ahmed</td>
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Abstract
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity. Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices

Lecture notes

Literature

Prerequisites / notice
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.
### Analytical Competencies

- **Concepts and Theories**
  - Constitutive models relevant for design and analysis of components and structures.
  - Theories for solving continuum mechanics problems.
- **Techniques and Technologies**
  - Numerical methods for FEA.
  - Computational techniques for simulation.
- **Analytical Competencies**
  - Problem-solving in non-linear FEA.
  - Decision-making in material selection.
  - Media and Digital Technologies.
  - Project Management.
- **Method-specific Competencies**
  - Nonlinear FEA.
  - Linear Elastic and Linear Viscous Material Behavior.
  - Anisotropic Elasticity.
  - Viscoelasticity.
  - Micro-Macro Modelling.
- **Social Competencies**
  - Communication.
  - Leadership and Responsibility.
  - Self-presentation and Social Influence.
  - Sensitivity to Diversity.
- **Personal Competencies**
  - Critical Thinking.
  - Integrity and Work Ethics.
  - Self-direction and Self-management.

### Subject-specific Competencies

- **Continuum Mechanics I**
  - Anisotropic Elasticity.
  - Linear Elastic and Linear Viscous Material Behavior.
  - Viscoelasticity.
  - Micro-Macro Modelling.
  - Laminate Theory.
- **Mechanics II: Nonlinear FEA**
  - Non-linear boundary conditions: contact problems.
  - Non-linear material behavior: hyperelasticity, plasticity.
  - Non-linear kinematics: large deformations, stability problems.
- **Lectures and computer labs** concerned with the modeling of the deformation response and failure of engineering materials (metals, polymers and composites) subject to extreme loadings during manufacturing, crash, impact and blast events.

### Method-specific Competencies

- **Dynamic Behavior of Materials**
  - Students will learn to apply, understand and develop computational models of a large spectrum of engineering materials to predict their dynamic deformation response and failure in finite element simulations.
- **Nonlinear FEA**
  - Course provides an introduction to non-linear finite element analysis.

### Personal Competencies

- **Critical Thinking**
  - Problem-solving.
  - Decision-making.
  - Media and Digital Technologies.
  - Assessment.

### Social Competencies

- **Communication**
  - Leadership and Responsibility.
  - Self-presentation and Social Influence.
  - Sensitivity to Diversity.

### Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Methods and Technologies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
<th>Project Management</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0525-00L Dynamic Behavior of Materials</td>
<td>yes</td>
<td>assessed</td>
<td>assessed</td>
<td>fostered</td>
<td>assessed</td>
<td>fostered</td>
<td>Communication</td>
<td>fostered</td>
</tr>
<tr>
<td>Objective</td>
<td>After successful completion of the course students are able to</td>
<td>• explain basic theories for solving continuum mechanics problems</td>
<td>• proficiently apply these theories by solving application-related academic examples</td>
<td>• relate the theories and examples to real engineering applications and challenges</td>
<td>• distinguish between different mechanical behaviors of materials</td>
<td>• systematically select appropriate constitutive theories suitable to analyze and model these materials</td>
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<tr>
<td>Content</td>
<td>Anisotropic Elasticity, Linear Elastic and Linear Viscous Material Behavior, Viscoelasticity, Micro-Macro Modelling, Laminate Theory, Plasticity, Viscoplasticity, Examples of Engineering Applications, Comparison with Experiments</td>
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<tr>
<td>Lecture notes</td>
<td>yes</td>
<td></td>
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<tr>
<td>Literature</td>
<td>Various books will be recommended pertaining to the topics covered.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Course in continuum mechanics (mandatory), finite element method (recommended)</td>
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</table>
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in Nonlinear Dynamics and Chaos I. The lecture introduces optical and imaging methods to assess structures and material parameters or validate numerical simulations. The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes.

A good overview on common optical methods is presented in the following textbooks:

- E. Mavrona
- W. Haller

Copies of the presented slides will be made available in advance through Moodle. These slide copies allow the students to add their notes and explanations given during the lecture. We will strive to provide summary pages for each lesson. We show how the methods can be applied to microsystems and large engineering structures. In addition, we explore time-resolved measurements in the context of modal analysis and dynamic events.

The lecture will take place two afternoons at Empa, where the students will gain first-hand experience with several optical methods in the laboratory. They will also experience the fabrication of thin films and 3D printing. Depending on the availability of the equipment and the student's interests, these hands-on classes may include, e.g., Digital Image Correlation, THz holography, Time-domain spectroscopy, Thermal Stress Analysis, ellipsometry, and fringe projection.

Lecture notes
Copies of the presented slides will be made available in advance through Moodle. These slide copies allow the students to add their notes and explanations given during the lecture. We will strive to provide summary pages for each lesson. Each lecture includes a set of exercises. Standard solutions for the exercises will be posted with a time lag.

Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

151-0535-00L  Optical Methods in Experimental Mechanics and Processing Technology

Abstract
The lecture introduces optical and imaging methods to assess structures and material parameters or validate numerical simulations. Selected fabrication technologies and their optical quality control methods are discussed, along with their strengths and limitations in industrial applications. The lecture includes two afternoons of hands-on-experience at Empa in Dübendorf.

Objective
The students can describe the process of imaging and image acquisition. They know how to design simple experiments based on optical and imaging methods. They understand the working principle of the optical techniques. Specifically, they can explain how a mechanical measure such as shape, deformation, and strain is transformed into an optical signal such as an interference, a change of the polarization state, or a change of surface temperature. They know the main application field of the individual techniques. They can choose the most appropriate method for solving a specific measurement task and estimate its expected resolution. In addition, they understand the basics of processing technologies from the clean room or 3D printing and how they can assess the quality of layers and structures. Through the hands-on experience, the students gain a more profound and sustained understanding by applying the theoretical foundations to tangible measurement tasks.

Content
After introducing optics and image acquisition, the lecture explains how to transform mechanical quantities such as shape, deformation, strain, or stress into image content. Selected applications to clean room processes for the fabrication of layered structures are explained. The measurement techniques make use of basic principles such as:
- Triangulation
- Interference
- Diffraction
- Birefringence
- Infrared radiation

Imaging techniques rely on area detectors, most notably CCD cameras, infrared sensors, and micro-bolometers. Natural white light, halogen lamps, and coherent light sources such as lasers will be used and demonstrated. The topics of the lecture include:
- Optics and imaging
- Digital Image Correlation (DIC) in 2D and 3D
- Diffraction and holography
- Terahertz (THz) techniques
- Simulations
- Device fabrication and 3D printing
- Photoelasticity and ellipsometry
- Thermoelastic Stress Analysis
- Validation of numerical models

We show how the methods can be applied to microsystems and large engineering structures. In addition, we explore time-resolved measurements in the context of modal analysis and dynamic events.

The lecture will take place two afternoons at Empa, where the students will gain first-hand experience with several optical methods in the laboratory. They will also experience the fabrication of thin films and 3D printing. Depending on the availability of the equipment and the student's interests, these hands-on classes may include, e.g., Digital Image Correlation, THz holography, Time-domain spectroscopy, Thermal Stress Analysis, ellipsometry, and fringe projection.

Lecture notes
Copies of the presented slides will be made available in advance through Moodle. These slide copies allow the students to add their notes and explanations given during the lecture. We will strive to provide summary pages for each lesson. Each lecture includes a set of exercises. Standard solutions for the exercises will be posted with a time lag.

151-0532-00L  Nonlinear Dynamics and Chaos I

Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
Prerequisites / notice
Basic knowledge of optics and interferometry, as taught in introductory physics courses, is advantageous. We encourage the audience to share their specific questions.

Competencies

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
<td>fostered</td>
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151-0544-00L Metal Additive Manufacturing - Mechanical Integrity and Process Simulation

W 4 credits 3G E. Hosseini

Note: The previous course title until HS22 "Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis".

Abstract
An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

Objective
The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using commercial analysis tools (e.g. ABAQUS) for simulation of the MAM process.

Content
- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (stainless steel, Ti6Al4V, Inconel 718),
- Design for additive manufacturing
- Artificial intelligence for AM

Exercise sessions use ABAQUS for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. Students can install the packages on their own systems.

Lecture notes
Handouts of the presented slides.

Literature
No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).

Prerequisites / notice
A basic knowledge of mechanical analysis, metallurgy, thermodynamics is recommended.

Competencies

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<td>Critical Thinking</td>
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151-0550-00L Adaptive Materials for Structural Applications

W 4 credits 3G A. Bergamini

Abstract
Adaptive materials offer appealing ways to extend the design space of structures by introducing time-variable properties into them. In this course, the physical working principles of selected adaptive materials are analyzed and simple models for describing their behavior are presented. Some applications are illustrated, also with laboratory experiments where possible.

Objective
The study of adaptive materials covers topics that range from chemistry to theoretical mechanics.

The aim of this course is to convey knowledge about adaptive materials, their properties and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.
This course will provide the students with an insight into the properties and physical phenomena which lead to the features of adaptive materials. Starting from chemomechanical (skeletal muscles), the physical behavior of a wide range of adaptive materials, thermo- and photo-mechanical, electro-mechanical, magneto-mechanical and meta-materials will be thoroughly discussed and analyzed. Up-to-date results on their performance and their implementation in mechanical structures will be detailed and studied in laboratory sessions. Analytical tools and energy based considerations will provide the students with effective instruments for understanding adaptive materials and assess their performance when integrated in structures or when arranged in particular fashions.

Basic concepts: Power conjugated variables, dissipative effects, geometry- and materials-based energy conversion
Thermo-mechanical coupling: Shape memory alloys / polymers
Electromechanical coupling(1): DEA, EBL, electrorheological fluids
Shape control / morphing: Use, requirements, challenges
Morphing applications of variable stiffness structures: Lab work
Electromechanical coupling (2): Piezoelectric, electrostrictive effect
Vibration Reduction: Measurement, passive, semi-active (active) damping methods
Vibration reduction applications of piezoelectric materials: Lab work
Metamaterials: Definition of metamaterials - electromagnetic, acoustical and other metamaterials

Energy harvesting and sensing: Energy harvesting with EAP and piezoelectric materials, transducers as sensors: Piezo, resistive,...

151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D’Andrea
Abstract Introduction to Dynamic Programming and Optimal Control.
Objective Covers the fundamental concepts of Dynamic Programming & Optimal Control.
Content Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.
Prerequisites / notice Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

151-0567-00L Engine Systems W 4 credits 3G C. Onder
Abstract Introduction to current and future engine systems and their control systems
Objective Introduction to methods of control and optimization of dynamic systems. Application to real engines. Understand the structure and behavior of drive train systems and their quantitative descriptions.
Content Physical description and mathematical models of components and subsystems (mixture formation, load control, supercharging, emissions, drive train components, etc.).
Lecture notes Case studies of model-based optimal design and control of engine systems with the goal of minimizing fuel consumption and emissions.
Prerequisites / notice Combined homework and testbench exercise (air-to-fuel-ratio control or idle-speed control) in groups

151-0569-00L Vehicle Propulsion Systems W 4 credits 3G C. Onder, P. Elbert
Abstract Introduction to current and future propulsion systems and the electronic control of their longitudinal behavior
Objective Introduction to methods of system optimization and controller design for vehicles. Understanding the structure and working principles of conventional and new propulsion systems. Quantitative descriptions of propulsion systems
Content Understanding of physical phenomena and mathematical models of components and subsystems (manual, automatic and continuously variable transmissions, energy storage systems, electric drive trains, batteries, hybrid systems, fuel cells, road/wheel interaction, automatic braking systems, etc.).
Lecture notes Presentation of mathematical methods, CAE tools and case studies for the model-based design and control of propulsion systems with the goal of minimizing fuel consumption and emissions.
Prerequisites / notice Lectures of Prof. Dr. Ch. Onder and Dr. Ph. Elbert are also possible to be held in German.

151-0593-00L Embedded Control Systems W 4 credits 6G C. Onder, M. Schmid Daners
Abstract This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.
Objective Familiarize students with main architectural principles and concepts of embedded control systems.
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

Detailed information can be found on the course website
http://www.dsc.ethz.ch/education/lectures/embedded-control-systems.html

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151-0602-00L

Microrobotics
W 4 credits 3G B. Nelson

Abstract
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

Lecture notes
The lecture will be taught in English.

Prerequisites / notice
The lecture notes, lab instructions, supplemental material

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151-0622-00L

Embedded MEMS Lab
W 5 credits 3P C. Hierold, A. Güntner, M. Haluska

Abstract
Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report.

Objective
Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

Content
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

Lecture notes
A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

Literature
The document provides sufficient information for the participants to successfully participate in the course.

Prerequisites / notice
Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscience Engineering (MAY-tutors Prof. Darsa, Dual, Hierold, Koumoutsakou, Nelson, Norris, Poulikakos, Pratsinis, Stemmmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

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151-0623-00L

Microsystems I: Process Technology and Integration
W 6 credits 3V+2U M. Haluska, C. Hierold

Abstract
Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).
Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps. This course aims to enhance the knowledge and competency of students regarding their innovation capability. An overview on prerequisites and different skills for creativity and innovation in individual & team settings is given. The focus of this lecture is clearly on building competencies - not just acquiring knowledge.

**Objective**
- Evaluating and developing individual skills for creativity building competencies - not just acquiring knowledge.

**Abstract**
For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry (the algorithms behind Hololens, Oculus Quest, and the NASA Mars rovers).

**Content**
- **Vision Algorithms for Mobile Robotics (University of Zurich)**
  No enrolment to this course at ETH Zurich, Book the corresponding module directly at UZH as an incoming student.

  **UZH Module Code:** DINF2039

  Mind the enrolment deadlines at UZH:

**Objective**
Learn the fundamental computer vision algorithms used in mobile robotics, in particular: filtering, feature extraction, structure from motion, multiple view geometry, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry and Simultaneous Localization And Mapping (SLAM) (the algorithms behind Hololens, Facebook-Oculus Quest, and the NASA Mars rovers).

**Content**
Each lecture will be followed by a lab session where you will learn to implement a building block of a visual odometry algorithm in Matlab. By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.

**Literature**
3. An Invitation to 3D Vision, by Y. Ma, S. Soatto, J. Kosecka, S. Sastry.

**Prerequisites / notice**
- Fundamentals of algebra, geometry, matrix calculus, and Matlab programming.

Note: If you are interested in taking UZH courses, you must register as an incoming mobility student at UZH. For details, see as follows:

UZH course enrollment for ETH student at University of Zurich (UZH) > Mobility within Switzerland – Incoming > Module Mobility: The easiest way to take individual modules/courses to supplement your studies at your home university is with module mobility. This option is not available to students who have dropped out of their home university or have been definitely excluded or banned from the relevant program or have failed to register. Attend the Application and Deadlines: Applications are submitted via the UZH application portal (https://www.uzh.ch/cmsssl/en/studies/application/chmobility.in.html)

Step-by-step guidelines on how ETH students can register for this course, are given on the official course website: [https://www.uzh.ch/cmsssl/en/studies/application/chmobility.html](https://www.uzh.ch/cmsssl/en/studies/application/chmobility.html)

ATTENTION: When you book the course at UZH, you are automatically registered for the exam at UZH and you can unregister until the October deadline. After registering for the course, you as an ETH student need to check out your **UZH email account** to receive the releated information from the lecturer.
Knowledge about prerequisites of creativity - theoretical models and empirical results:
- Motivation
- Domain knowledge
- Thinking processes

Development of individual skills for creativity:
- Focus on creativity as problem analysis & solving
- Individual skill exercises and reflection

Knowledge about teams - theoretical models and empirical results:
- Team climate, Psychological Safety
- Team development
- Creative problem solving in teams

Facilitating creative team processes:
- The role of the team facilitator
- Cooperation and communication in innovation teams

Development of team-oriented skills for creativity:
- Idea generation and development in teams
- Cooperation and communication in innovation teams

Lecture notes
Slides, script and other documents will be distributed via moodle.ethz.ch
(access only for students registered to this course)

Literature
As well as material handed out in the lecture

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

151-0703-00L Operational Simulation of Production Lines W 4 credits 2V+1U P. Acél, A. Kunz

Abstract
The students learn the application of the event-based and computer-based simulation for layout and improvement of production facilities by means of practical examples and by using the so-called «Digital Twin» within the context of «Industry 4.0». They learn how virtual and mixed reality tools can be used together with the Digital Twin to plan and support the operation of a production line.

Objective
The students learn the correct use of (Who? When? How?) of the event-driven and computer-based simulation in the illustration of the operating procedures and the production facilities. The simulation is an important basis for creating a digital twin in the context of Industry 4.0.
Operating simulation in the productions, logistic and scheduling will be shown by means of practical examples.
The students should make their first experiences in the use of computer-based simulation.
Further, the lecture gives insights into the methods-time measurement (MTM) for evaluating human work places as basis for the simulation and learn how this is performed using virtual reality.

Content
- Application and application areas of the event-driven simulation
- Simulation in the context of Industry 4.0 (digital twin)
- Exemplary application of a software tool (Technomatrix-Simulation-Software)
- Internal organization and functionality of simulation tools
- Procedure for application: optimizing, experimental design planning, analysis, data preparation
- Controlling philosophies, emergency concepts, production in sequence, line production, rescheduling
- Application on the facilities projecting
- Applications of Virtual and Mixed Reality

The knowledge is enhanced by practice-oriented exercises and an excursion. A guest speaker will present a practical example.

Lecture notes
Will be sent by email before the lecture (pdf).

Literature
A bibliography will be handed out during the lectures.

Prerequisites / notice
Recommended for all Bachelor-Students in the 5th semester and Master-Students in the 7th semester (MAVT, MTEC, PhD students in material sciences) and for all with interest in production (e.g., MTEC, HEST, etc.)
Stochastic Methods for Engineers and Natural Scientists

The course provides an introduction into stochastic methods that are applicable for the description, treatment, and modeling of systems that are subject to uncertainties or that respond to parameter changes in a chaotic manner. Corresponding systems may arise in fluid dynamics, structural mechanics, biology, electrical engineering as well as other areas.

The lecture concludes with an excursion to a large manufacturing company. Here, students can the see the application and realization of the manufacturing of electric and electronic devices.

The lecture starts with a brief introduction of electronic components and the planning of integrated circuits. Next, an overview will be provided about electronic functional units assembled from these electronic components, on printed circuit boards as well as in hybrid technology. Value added process steps are shown as well as their quality check and their combination for planning a complete manufacturing line. The lecture further describes the manufacturing of integrated circuits, starting from the wafer via the structuring and bonding to the packaging. As an example, the manufacturing of micro-electromechanic and electro-optical systems and actuators is described. Due to similar processes in the electronic production, the value added process sequence for photovoltaics will be described too.

The course provides knowledge about the value added process sequence for electronics manufacturing, planning of electric and electronic product as well as their production, planning of production lines, value added process sequence for photovoltaics.

The lecture follows the value added process sequence of electric and electronic components. It contains: Development of electric and electronic circuits, design of electronic circuits on printed circuit boards as well as in hybrid technology, integrated test technology, planning of production lines, production of highly integrated electronic on a wafer as well as recycling.

The lecture concludes with an excursion to a large manufacturing company. Here, students can see the application and realization of the manufacturing of electric and electronic devices.

Lecture notes are handed out during the individual lessons.
Prerequisites / notice

The lecture is partly given by experts from industry. It is supplemented by an excursion to one of the industry partners.

Competencies

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Exciting Leadership in a Thrilling Real Business World

Abstract

What is leadership in a real world? What are the preconditions of personal leadership? What is the differences between Leadership and Management? What is the price to be payed to be a Leader? What are the core competences of a Leader? How to become an inspiring Leader? How to experience exciting leadership in a thrilled real business world.

Objective

The objective of this course is to understand the impact of Leadership and to learn based on longterm international leadership experiences very practicate competences and skills needed to be a leader.

Content

Definitions and methods what leadership is about based on real industrial examples. Levels of Leadership. Conflicts, challenges and risks of Leaders. Competences of a leader such as: decision making processes, communication, emotional intelligence, change processes and understanding of people behaviours.

Competencies

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Colloquium on Manufacturing Technology

Abstract

Future training on selected current topics of the manufacturing technology. Per afternoon a selected topic is presented in several lectures, by the majority by experts from the industry. The students prepare a summary of the lectures given and prepare themselves on the basis of these lectures and own information search.

Objective

Continuous further training to current topics of the manufacturing technique. Exchange of experience and knowledge with the industry and other universities.

Content

Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

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Sustainable Materials

Abstract

The lecture addresses the issue of sustainability in manufacturing, focussing on materials. The most used materials, their production and transformation into a product are analysed in terms of energy consumption and emissions. Emphasis is then placed on alternative design strategies which reduce the use of materials and innovative processes which lower energy consumption and emissions.

Objective

After this lecture students will be able to:

- Develop a critical thinking of published sustainability data and facts
- Explain where the materials that we use come from, what emissions arise from the different steps of raw material production and product manufacturing
- Determine where significant changes can be brought
- Develop feasible solutions towards a more sustainable use of materials
Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite Element Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:

- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model of a complex non linear system will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

- introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

The primary objective of this course is to provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

The course consists of three parts: First, we will refresh and deepen the student's knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrrotores and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.
Introduction to Photonics

W 4 credits  2V+2U  R. Quidant, J. Ortega Arroyo

Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.

Content
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel coefficients
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Applications of optical tweezers

VII- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging
### 151-0917-00L  
**Mass Transfer**  
**W** 4 credits  
**2V+2U**  
M. Tibbitt, V. Mavrantzas, C.-J. Shih

**Abstract**  
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.

**Objective**  
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore, the application of these principles to important engineering problems is demonstrated.

**Content**  
- Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

**Literature**  

**Prerequisites / notice**  
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

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### 151-0927-00L  
**Rate-Controlled Separations in Fine Chemistry**  
**W** 6 credits  
**3V+1U**  
M. Mazzotti, V. Becattini, N. Casas, F. Kiefer

**Abstract**  
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

**Objective**  
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

**Content**  
The class covers separation techniques that are central in the purification and downstream processing of chemicals and biopharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

**Literature**  
Recommendations for text books will be covered in the class

**Prerequisites / notice**  
Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)

**Competencies**

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Molecular Sensors: From Fundamentals to Health and Environmental Applications

Abstract
Molecular sensors are used in everyday life in health care, environmental monitoring, food safety, space and other fields. Sources of molecular information, its transport and fundamental concepts of molecular sensing will be discussed. In the scope of group projects, the acquired knowledge will be applied and deepened in case studies.

Objective
After the course, the students will:

- know the requirements and merits of molecular sensors for health, environmental and other emerging applications (e.g. space)
- understand transport phenomena of molecular information & surface interactions and know how to quantitatively describe these
- understand fundamental sensing concepts for the detection and quantification of molecular analytes
- know concepts of signal processing
- be capable to apply the learnt knowledge to conceive and engineer sensor concepts and systems
- know how to investigate sensor-related literature and present scientific data

This course consists of a theoretical and a project-based learning block. In the first 10 semester weeks, theoretical knowledge will be provided through lectures and deepened in corresponding exercises. In the last 4 weeks, the students will apply the learned concepts through group projects to investigate case studies. The outcome will be present.

Content
Transport of Molecular Information; Surface Interactions; Sensor Fundamentals; Chemoresistive Sensing; Electrochemical Sensing; Mass-sensitive; Capacitive Sensing; Signal Processing; Medical Requirements for Molecular Sensing

Lecture notes
Hand-outs will be provided to each lecture including the exercises and their solutions.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Sensitivity to Diversity fostered

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered

Process Design and Safety

Abstract
The lecture Process Design and Saftey deals with the fundamentals of project management, scale-up, dimensioning and safety of chemical process equipment and plants.

Objective
The objective of the lecture is to expound the engineering design approach of important elements in chemical plant design.

Content
Fundamentals in Chemical engineering Design;
- Project Management,
- Cost estimate,
- Materials and Corrosion,
- Piping and Armatures,
- Pumps,
- Reactors and Scale-up,
- Safety of chemical processes,
- Patents

Lecture notes
The lecture slides will be distributed.

Prerequisites / notice
A 1-day excursion including a visit of a chemical plant will be part of the lecture.

Introduction to Aircraft and Car Aerodynamics

Abstract

Objective
To understand the basic relations of the origin of aerodynamic forces (ie lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components.

Content
- Aircraft aerodynamics: atmosphere, aerodynamic forces (ascending force; profile, wings. Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.

Lecture notes
Preparation materials & slides are provided prior to each class
1. Optimization modeling and theory
2. Unconstrained optimization methods
3. Constrained optimization methods - linear and non-linear
4. Adaptability and Flexibility

Engineering Design Optimization

Objective
- Critical thinking and reasoned judgements
- Basic knowledge about role and mindset of a coach
- Understanding the challenges of engineering projects and design teams
- Development of personal skills to apply and train product development methods
- Knowledge and know-how about applying methods
- Reflection and exchange of experiences about personal coaching situations
- Inspiration and learning from good cases regarding organizational and team management aspects
- Decision-making under uncertainty

Content
- Kick-off & Experience Exchange
- Coaching Role
- Active Listening
- Giving and Receiving Feedback
- Team Building & Psychological Safety
- Building Hypotheses in the coaching process
- Conflict resolution and motivation

In addition to the content topics, one-on-one coaching will be provided and classes will reflect on current, practical issues derived from coaching of the innovation teams.

Prerequisites / notice
Only for participants (Bachelor Students, Master Students) who are teaching assistants in the innovation project.

Competencies
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Literature
- Aircraft Aerodynamics:
  - Schlichting, H und Truckenbrodt, E: Aerodynamik des Flugzeuges (Ed I und II), Springer Verlag, 1960
  - Hoerner, S.F.: Fluid Dynamic Lift, Hoerner Fluid Dynamics, 1975

Vehicle Aerodynamics

Design for Additive Manufacturing

Objective
- Apply basic AM processes (metal and plastic)
- Apply AM design guidelines
- Adopt AM in an industrial environment
- Apply design tools and methods in AM
- Create value from AM
- Work in a project based product development team

Content
- Design a product with additive manufacturing in mind
- Learn about different AM processes and materials
- Understand the limitations and advantages of AM
- Create a functional prototype using AM

Lecture notes available on Moodle
Content
In parallel to the lectures, the students design, manufacture and test prototypes in a project at different stages of product development. The course covers the following topics:
- State-of-the-art AM processes for metals and plastics: PBF (also known as SLM, SLS), BJT, MJF, MEX (FDM)
- Design guidelines in AM
- Industrial adoption of AM
- Value creation and business models for AM
- Design tools and methodologies for AM
- Quality management in AM
- Industrial cases of AM applications
- Problem solving and creativity
- Agile development

Lecture notes
Script and handouts are available in PDF-format.

Literature
Christoph Klahn; Mirko Meboldt: Entwicklung und Konstruktion für die Additive Fertigung - Grundlagen und Methoden für den Einsatz in industriellen Endkundenprodukten
Vogel Business Media, Würzburg
ISBN: 978-3-8343-3395-7

Ian Gibson; David Rosen; Brent Stucker: Additive manufacturing technologies - 3D printing, rapid prototyping, and direct digital manufacturing
Springer, New York
ISBN: 978-1-4939-2112-6

Prerequisites / notice
This course is for master’s students.

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151-8101-00L International Engineering: from Hubris to Hope
W 4 credits 3G E. Tilley

Abstract
Since Europe surrendered their colonial assets, engineers from rich countries have returned to the African continent to address the real and perceived ills that they felt technology could solve. And yet, 70 years on, the promise of technology has largely failed to deliver widespread, substantive improvements in the quality of life. Why?

Objective
This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to examine the complex role that well-meaning foreigners have played and continue to play in the disappointing health outcomes that characterize much of the African continent.

After completing the course, participants will be able to
- critique the jargon and terms used by the international community, i.e. “development”, “aid”, “cooperation”, “assistance” “third world” “developing” “global south” “low and middle-income” and justify their own chosen terminology
- recognize the role of racism and white-supremacy in the development of the Aid industry
- understand the political, financial, and cultural reasons why technology and infrastructure have historically failed
- Debate the merits of international engineering in popular culture and media
- Propose improved SDG indicators that address current shortcomings
- Compare the engineering curricula of different countries to identify relative strengths and shortcomings
- Explain the inherent biases of academic publishing and its impact on engineering failure
- Analyse linkages between the rise of philanthropy and strategic priority areas
- Recommend equitable, just funding models to achieve more sustainable outcomes
- Formulate a vision for the international engineer of the future

Content
Role of international engineering during colonialism
Transition of international engineering following colonialism
White saviourism and racism in international engineering
International engineering in popular culture
The missing role of Engineering Education
Biases in academic publishing
The emerging role in Global Philanthropy
The paradox of International funding

Literature
### Applied Category Theory for Engineering I

**Note:** The previous course title until HS22 "Applied Compositional Thinking for Engineers II"

**W 4 credits 3G A. Censi, J. Lorand**

**Abstract**
Applied Category Theory is an exciting multidisciplinary field of research which harnesses the mathematical language of category theory for applications across a broad range of disciplines. This course is a gentle introduction focused on applications in engineering and the "compositional approach" to systems analysis, co-design, and computation.

**Objective**
1) Learn basic concepts from algebra and category theory, together with ways to make use of these concepts for engineering applications.
2) Become familiar with case studies of applied category theory, for instance involving dynamical systems, databases, and complex system co-design (e.g. in the context of autonomous vehicles).
3) Be able to recognize compositional structures in concrete scenarios at different levels of abstraction.
4) Understand the "compositional way of thinking" as an approach to systems analysis, co-design, and computation.

**Content**
Review of basic algebraic structures [sets, relations, (semi)groups, monoids, actions, order theory]

Gentle introduction to category theory [series and parallel composition, feedback, actions, functors, universal properties]

Many simple applied examples illustrating concepts along the way. Extended examples from dynamical systems, databases, and systems co-design in engineering.

Homework will consist of 1) basic exercises to check one's understanding of core concepts, and 2) a choice between either A) coding exercises (in python) to learn how to implement concepts in software or B) further theory exercises to deepen mathematical understanding.

Homework will be graded on a schedule that allows some flexibility, and it will constitute 100% of the grade (no exam).

**Lecture notes**
Slides and a (work-in-progress) textbook for the course will be provided (A. Censi, J. Lorand, G. Zardini, "Applied Compositional Thinking for Engineers").

**Literature**

Supplementary references include the following books:
Fong, Spivak, "An invitation to applied category theory: Seven sketches in compositionality"

Spivak, "Category theory for the sciences"

A knowledge of algebra at the level of a bachelor's degree in engineering/computer science.

### Structural Reliability and Risk Analysis

**W 3 credits 2G S. Marelli**

**Abstract**
Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.

**Objective**
The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in engineering. Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SI or Euro-codes usually provide a framework that guarantees safety and reliability. However, the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FORM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

Lecture notes
Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.

Literature

Prerequisites / notice
Basic course on probability theory and statistics

227-0124-00L Embedded Systems

Abstract
An embedded system is a combination of hardware and software, either fixed in function or programmable, that is designed for a specific application scenario or for a specific task within a larger system. They are part of industrial machines such as agricultural and manufacturing equipment, automotive systems, medical equipment, household appliances, sensor networks, and the Internet of Things.

Objective
Understanding the specific requirements and problems that arise in embedded system applications.

Understanding the hardware structure of a microcontroller and an embedded system; memory architecture and memory map, internal and external peripherals, low-power and low-energy design as well as instruction sets and computational accelerators.

Understanding the firmware structure of a microcontroller and an embedded system; low-level instruction set, hardware-software interfaces, communication between components, embedded real-time operating systems, real-time scheduling, shared resources, low-power and low-energy programming as well as computational accelerators.

Using formal models and methods for designing and optimizing embedded systems.

Gaining experience with practical applications of the C programming language, embedded real-time operating systems, and debug functionalities of the associated design environment to design, implement, and verify embedded firmware.

Through project-based activities, students will gain substantial experience in applying the C programming language in the context of embedded systems. Projects will involve developing and implementing firmware, utilizing embedded real-time operating systems, and exploring the debugging functionalities within design environments. This hands-on approach aims to bridge the gap between theoretical knowledge and practical application, allowing students to experience the full lifecycle of embedded system development from design to implementation and verification.

Content
This lecture focuses on the design of embedded systems using formal models and methods.

Besides the theoretical lecture, the course contains laboratory sessions where students transfer the learned theoretical aspects into praxis by programming a microcontroller and interfacing it with sensors and actuators. Students will be exposed to a commercial microcontroller, and the development board extend with a custom-designed embedded systems educational platform.

Specifically, the following topics will be covered in the course: hardware and software structures of embedded systems, low-level instruction set, memory architecture and memory map, peripherals, hardware-software interfaces, communication between components, firmware design methodologies, firmware design using the C programming language, embedded real-time operating systems, real-time scheduling, shared resources, low-power, and low-energy designs as well as computational accelerators.

Lecture notes
Lecture material, publications, exercise sheets, and laboratory documentation will be available on the course's Moodle page.

Literature

Prerequisites / notice
Prerequisites: C programming, circuit theory, digital logic, binary number representations.

Competencies
Recommended: basic knowledge of assembly programming and computer architecture.

227-0225-00L Linear System Theory

Abstract
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.
Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes
Available on the course Moodle platform.

Prerequisites / notice
Sufficient mathematical maturity, in particular in linear algebra, analysis.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Abstract
Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective
Upon completion of the course students are able to:
- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.
Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optical components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.

Lecture notes

Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice
No specific requirements, BUT
ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while
HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content
Lecture topics:
1. Introduction
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

Measuring biochemical signals

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics.
In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience fostered Analytical Competencies

Concepts and Theories assessed Techniques and Technologies assessed

Analytical Competencies assessed Decision-making fostered

Media and Digital Technologies fostered Problem-solving assessed

Project Management fostered

Communication fostered Cooperation and Teamwork fostered

Customer Orientation fostered Leadership and Responsibility fostered

Self-presentation and Social Influence fostered Sensitivity to Diversity fostered

Negotiation fostered

Adaptability and Flexibility fostered

Creative Thinking assessed

Critical Thinking assessed

Integrity and Work Ethics fostered Self-awareness and Self-reflection fostered

Self-direction and Self-management fostered

Image Analysis and Computer Vision

W 6 credits 3V+1U

E. Konukoglu, E. Erdil, F. Yu

Abstract


Objective

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

Content

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

Fundamentals of Electric Machines

W 6 credits 4G

D. Bortis

Abstract

This course introduces different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

Objective

The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

Content

- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes

Lecture notes and associated exercises including correct answers

Competencies

Subject-specific Competencies Concepts and Theories assessed Techniques and Technologies assessed

Method-specific Competencies Analytical Competencies assessed Decision-making fostered

Problem-solving fostered

Railway Systems I

W 6 credits 4G

M. Meyer

Abstract

Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance
Objective
- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

Content
EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale

1 Einführung:
1.1 Geschichte und Struktur des Bahnsystems
1.2 Fahrdynamik

2 Vollbahnfahrzeuge:
2.3 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
2.2 Bremsen
2.3 Traktionsantriebsysteme
2.4 Hilfsbetriebe und Komfortanlagen
2.5 Steuerung und Regelung

3 Infrastruktur:
3.1 Fahrbahn
3.2 Bahnstromversorgung
3.3 Sicherungsanlagen

4 Betrieb:
4.1 Interoperabilität, Normen und Zulassung
4.2 RAMS, LCC
4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Geplante Exkursionen:
- Betriebszentrale SBB, Zürich Flughafen
- Reparatur und Unterhalt, SBB Zürich Altstetten
- Fahrzeugfertigung, Stadler Bussnang

Lecture notes
Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice
Dozent: Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Techniques and Technologies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
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</table>

252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.
At the end of the course, the students will be able to build a rendering system based on path-tracing algorithms. The students will learn the principles of physically-based rendering and computer graphics. In addition, the course is intended to stimulate the student's curiosity to explore the field of computer graphics in subsequent classes or on their own.

We will begin with an introduction to light emission and radiometric quantities, followed by an exploration of geometry representations and texture mapping.

Next, we will mathematically formulate the physics of light transport and appearance modeling. Subsequently, we will introduce relevant concepts from Monte Carlo integration and develop path-tracing algorithms to solve these equations by simulating light transport for direct and global illumination due to hard surfaces and participating media, such as fog, smoke, and translucent objects.

Moreover, we will present techniques for significantly improving path-tracing efficiency, including importance sampling, stratified sampling, denoising, and acceleration data structures. The course lectures will conclude with an overview of image-based capture and rendering methods. Topics covered will include geometry reconstruction, material acquisition, differentiable rendering, and image-based rendering.

The programming assignments will be in C++. This will not be taught in the class.

Computers Graphics

<table>
<thead>
<tr>
<th>Content</th>
<th>Objective</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
</table>
| This course covers fundamental and advanced concepts of modern computer graphics. Students will learn the fundamentals of digital scene representations, advanced physically-based light transport algorithms for generating photorealistic images from these scene representations, and inverse rendering methods for recovering digital scene representations from captured images. | At the end of the course, the students will be able to build a rendering system based on path-tracing algorithms. The students will learn the principles of physically-based rendering and computer graphics. In addition, the course is intended to stimulate the student's curiosity to explore the field of computer graphics in subsequent classes or on their own. | The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

I am willingly available Mondays 17.00 o'clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

!!! I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle !!!

Literature


As further deepening:


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

227-0981-00L Cross-Disciplinary Research and Development in Medicine and Engineering

A maximum of 12 medical degree students and 12 (biomedical) engineering degree students can be admitted, their number should be equal.

V. Kurtcuoglu, D. de Julien de Zelicourt, M. Meboldt

W 4 credits 2V+2A

IMPORTANT: Note that a special permission from the lecturers is required to register for this course. Contact the head lecturer to that end.
Abstract
Cross-disciplinary collaboration between engineers and medical doctors is indispensable for innovation in health care. This course brings together engineering students from ETH Zurich and medical students from the University of Zurich to experience the rewards and challenges of such interdisciplinary work in a project based learning environment.

Objective
The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since such differences become most evident during actual collaborative work, the course is based on a project in physiology, medical or clinical research that combines medicine and engineering.

For the engineering students, the specific aims of the course are to:
- Identify and precisely define a clinical need;
- Acquire a working understanding of the investigated system;
- Identify the engineering challenges in the project and communicate them to the medical students;
- Develop and implement, together with the medical students, solution strategies for the identified challenges;
- Present the solution concept to a cross-disciplinary audience; Preliminary need and solution validation;

Content
After a general introduction to interdisciplinary communication, need identification and product development, the engineering students will team up with medical students to 1) identify a clinically relevant need, 2) develop early-stage solution concepts to it. In the process, they will be supervised both by lecturers from ETH Zurich and the University of Zurich, receiving coaching customized to the project. The project is usually defined by the team itself, but can also be guided by the lecturers. The course will end with each team presenting identified need and solution concept to a cross-disciplinary audience.

Lecture notes
Lecture handouts and relevant material will be provided.

Prerequisites / notice
IMPORTANT: Note that a special permission from the lecturers is required to register for this course. Contact the head lecturer to that end.

Competencies

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility fostered
Negotiation fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

227-0965-00L Micro and Nano-Tomography of Biological Tissues
W 4 credits 3G M. Stampanoni, F. Marone Welford

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes
Available online

Literature
Will be indicated during the lecture.

252-0834-00L Information Systems for Engineers
W 4 credits 2V+1U G. Fourny

Abstract
This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.

2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).

3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.

4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality

5. Explain what bad design is and why it matters.

6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".

7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.

8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.

9. Explain what data independence is all about and didn't age a bit since the 1970s.

10. Explain, in the big picture, how a relational database is physically implemented.

11. Know and deal with the natural syntax for relational data, CSV.

12. Explain the data cube model including slicing and dicing.

13. Store data cubes in a relational database.

14. Map cube queries to SQL.

15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (it is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
The course provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.

The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As well as understand the basic notions of Computational Design in a HCI context.

The course will introduce students to several methods of analysing the user experience, showing how these can be used at different stages of system development from requirements analysis through to usability testing.

Students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

### 263-5210-00L Probabilistic Artificial Intelligence

**Abstract**
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

**Content**
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

**Prerequisites / notice**
Solid basic knowledge in statistics, algorithms and programming.

**Competencies**

<table>
<thead>
<tr>
<th>Competency Type</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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**Methods and Technologies**
- Reinforcement learning
- Probabilistic planning
- Bayesian learning
- Gaussian processes
- Variational inference
- Bayesian inference
- MCMC
- Multi-armed bandits
- Bayesian optimization

The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.

### 263-5902-00L Computer Vision

**Abstract**
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

**Objective**
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

**Content**
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

### 263-5910-00L Open- and User Innovation

**Abstract**
The course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.

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The course includes both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active class participation is required.

This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

This core course provides insights into the basic theories, principles, and techniques used to design, analyze, and improve the operational capabilities of an organization.

After completing this course:
1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

The course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM

Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.
The learning objectives include:

1. advanced knowledge of the state-of-the-art in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.
Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions courses focused on QUality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A).

Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.
Objective
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

W 3 credits 2V R. Rienner, O. Lambercy

Abstract
Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Content
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
- Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
- Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
- Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
- Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces
Literature

Introductory Books:


Selected Journal Articles and Web Links:


Prerequisites / notice

Target Group:

- Students of higher semesters and PhD students of D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

376-1504-00L Physical Human Robot Interaction (pHRI)  W  4 credits  2V+2U  O. Lambercy, P. Wolf

Abstract

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.
**Objective**

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

**Content**

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

**Lecture notes**

Will be distributed on Moodle before the lectures.

**Literature**


**Prerequisites / notice**

Notice:
The registration is limited to 26 students
There are 4 credit points for this lecture.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes.

http://www.relab.ethz.ch/education/courses/phri.html
The course gives an introduction into bone biology and provides an overview on current research methods and clinical approaches. After completing the Bone Biology course, students will be able to:

- Handouts are deposited online (moodle).
- Literature: Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Project Management
- Communication
- Cooperation and Teamwork
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

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<th>Concepts and Theories</th>
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### 376-1651-00L Clinical and Movement Biomechanics

**W** 4 credits 3G  D. K. Ravi, S. H. Hosseini Nasab, R. List, further lecturers

**Abstract**
Measurement and modeling of the human movement during daily activities and in a clinical environment.

**Objective**
The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

**Content**
This course includes study design, measurement techniques, clinical testing, accessing movement data and anysis as well as modeling with regards to human movement.

### 376-1714-00L Biocompatible Materials

**W** 4 credits 3V  K. Maniura, M. Rottmar, M. Zenobi-Wong

**Abstract**
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**
Handouts are deposited online (moodle).

**Literature**

(available online via ETH library)

**376-1721-00L Bone Biology: Basics, Research and Clinics**

**W** 2 credits 2V  E. Wehrle, G. A. Kuhn, to be announced

**Abstract**
The course gives an introduction into bone biology and provides an overview on current research methods and clinical approaches. Emphasis is put on skeletal development and metabolism, osteoporosis as well as fracture healing. Each topic is structured into three parts: basics, research and clinics.

**Objective**
After completing the Bone Biology course, students will be able to:
1. Remember and apply basics in bone biology and disease
2. Remember clinical features and surgical approaches
3. Select adequate research methods and approaches
4. Evaluate publications on topics presented in the lecture

**Competencies**
- Subject-specific Competencies: Concepts and Theories
  - assessed
- Technique and Technologies: assessed
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered
- Social Competencies: Communication
  - fostered
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Personal Competencies: Adaptable and Flexible
  - fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**376-1985-00L Trauma Biomechanics**

**W** 4 credits 2V+1U  K.-U. Schmitt, M. H. Muser

**Abstract**
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.
Introduction to Mathematical Optimization

Objective
Introduction to the basic principles of trauma biomechanics.

Content
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

Lecture notes
Handouts will be made available.

Literature

Methods

Method-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies assessed
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies

- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity assessed
- Negotiation fostered

Personal Competencies

- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered
Lecture notes: Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature: Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice: To attend this course, the students must have a solid basic knowledge in chemistry, biochemistry, and general biology. The course will be taught in English.

Competencies: Subject-specific Competencies

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► Multidisciplinary Courses

The students are free to choose individually Master's courses from the Course Catalogue of ETH Zurich, ETH Lausanne, and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Course Catalogue of ETH Zurich

► Semester Project

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<tr>
<td>151-1002-00L</td>
<td>Semester Project Mechanical Engineering</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract: The subject of the Semester Project and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

Objective: The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

► Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>8 credits</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>


Objective: The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

► Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

► Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1001-00L</td>
<td>Master's Thesis Mechanical Engineering</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract: The Master's Thesis must be approved in advance by the tutor and supervised by a professor of ETH Zurich.

Objective: Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

► Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>406-0173-AAL</td>
<td>Linear Algebra I and II</td>
<td>E</td>
<td>6 credits</td>
<td>13R</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

Abstract: Linear algebra is an indispensable tool of engineering mathematics. The course is an introduction to basic methods and fundamental concepts of linear algebra and its applications to engineering sciences.

Objective: After completion of this course, students are able to recognize linear structures and to apply adequate tools from linear algebra in order to solve corresponding problems from theory and applications. In addition, students have a basic knowledge of the software package Matlab.
Content
Linear maps, kernel and image, coordinates and matrices, coordinate transformations, norm of a matrix, orthogonal matrices, eigenvalues and eigenvectors, algebraic and geometric multiplicity, eigenbasis, diagonalizable matrices, symmetric matrices, orthonormal basis, condition number, linear differential equations, Jordan decomposition, singular value decomposition, examples in MATLAB, applications.

Reading:
Gilbert Strang "Introduction to linear algebra", Wellesley-Cambridge Press: Chapters 1-6, 7.1-7.3, 8.1, 8.2, 8.6

Literature

401-0363-AAL Analysis III
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

Content
Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Literature

For reference/complement of the Analysis I/II courses:
Christian Blatter: Ingenieur-Analysis (Download PDF)

Prerequisites / notice
Up-to-date information about this course can be found at:
http://www.math.ethz.ch/education/bachelor/lectures/hs2013/other/analysis3_itet

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

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Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
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Objective
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- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

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- Functions of Any Period p=2L
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- Approximation by Trigonometric Polynomials
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- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
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- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Code</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Eligible for credits and</td>
<td>W+</td>
<td>Recommended</td>
</tr>
<tr>
<td>Eligible for credits</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>Recommended, not eligible for</td>
<td>E-</td>
<td>credits</td>
</tr>
<tr>
<td>Courses outside the curriculum</td>
<td>Z</td>
<td></td>
</tr>
<tr>
<td>Suitable for doctorate</td>
<td>Dr</td>
<td></td>
</tr>
<tr>
<td>Compulsory</td>
<td>O</td>
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<table>
<thead>
<tr>
<th>Key for Hours</th>
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<tr>
<td>lecture</td>
<td>V</td>
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</tr>
<tr>
<td>lecture with exercise</td>
<td>G</td>
<td></td>
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<tr>
<td>exercise</td>
<td>U</td>
<td></td>
</tr>
<tr>
<td>seminar</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>colloquium</td>
<td>K</td>
<td></td>
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<tr>
<td>practical/laboratory course</td>
<td>P</td>
<td></td>
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<tr>
<td>independent project</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>diploma thesis</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>revision course / private study</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
**Educational Science**

General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0240-00L</td>
<td>Cognitive Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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<td></td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td></td>
<td>- Get information about recent literature on learning and instruction</td>
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<td></td>
<td>Prerequisites / notice</td>
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<td></td>
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</tr>
<tr>
<td>871-0242-06L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;</td>
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<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td></td>
<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<tr>
<td></td>
<td>- Understanding of research methods used in the empirical human sciences</td>
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<td></td>
<td>- Getting to know intelligence tests</td>
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<td></td>
<td>- Understanding findings relevant for education</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td></td>
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</tr>
<tr>
<td>871-0242-07L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W)</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>S. Maurer, P. Caprez, I. Sargenti</td>
</tr>
<tr>
<td></td>
<td>The successful participation in EW1 (&quot;Human Learning&quot;) and EW2 (&quot;Designing Learning Environments for School&quot;) is recommended, but not a mandatory prerequisite.</td>
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<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td></td>
<td>In this class, students will learn concepts and skills for coping with psychosocial demands of teaching</td>
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<tr>
<td></td>
<td>Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.</td>
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<tr>
<td></td>
<td>(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parent-teacher meetings).</td>
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<tr>
<td></td>
<td>(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. legal or psychological services).</td>
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</tr>
<tr>
<td>871-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Markwalder</td>
</tr>
<tr>
<td></td>
<td>Adresses to students enrolled either in Teaching Diploma (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).</td>
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<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in the course 871-0240-00L &quot;Human Learning&quot;</td>
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</tr>
</tbody>
</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1817 of 2667
**Learning (EW 1)**

**Abstract**
Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar (ca. 16 h), 2) collaboration with elementary school teacher in a class (ca. 34 h, with approx. 50% spent in the elementary or middle school class and ca. 50% for preparation), and 3) final report (ca. 10 h). Registration implies participation in all 3 parts.

**Objective**
Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.).

**Content**
Students learn more about the potential and challenges of pupils. They get to know the early stages of knowledge as well as the development of pre-concepts of students in their subject area. The seminar with a phase of cooperation consists of three phases: In the block seminar, pre-concepts are discussed in their own subject as well as theoretical inputs from developmental and cognitive psychology. During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students’ level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

**Prerequisites / notice**
https://www.minterlink.ch/student

**Competencies**

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Competencies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
</tr>
</tbody>
</table>

**Subject Didactics and Professional Training**

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1079-00L</td>
<td>Teaching Internship Including Examination Lessons</td>
<td>W</td>
<td>6</td>
<td>13P</td>
<td>Q. Lohmeyer</td>
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<tr>
<td></td>
<td>Mechanical and Process Engineering</td>
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<td></td>
<td>The teaching internship can just be visited if all other courses of TC</td>
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<td></td>
<td>are completed.</td>
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<td></td>
<td>Repetition of the teaching internship is excluded even if the exam</td>
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<tr>
<td></td>
<td>inations lessons are to be repeated.</td>
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<tr>
<td></td>
<td>The teaching internship can just be visited if all other courses of TC</td>
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<td></td>
<td>are completed.</td>
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<td>Repetition of the teaching internship is excluded even if the exam</td>
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<tr>
<td></td>
<td>inations lessons are to be repeated.</td>
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<tr>
<td>Abstract</td>
<td>Students apply the insights, abilities and skills they have acquired</td>
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<tr>
<td></td>
<td>within the context of an educational institution. They observe 10</td>
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<td></td>
<td>lessons and teach 20 lessons independently. Two of them are as</td>
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<td></td>
<td>assessed as Examination Lessons.</td>
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<tr>
<td>Objective</td>
<td>- Students use their specialist-subject, educational-science and</td>
<td></td>
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<tr>
<td></td>
<td>subject-didactics training to draw up concepts for teaching.</td>
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<tr>
<td></td>
<td>- They are able to assess the significance of tuition topics for</td>
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<tr>
<td></td>
<td>their subject from different angles (including interdisciplinary angles)</td>
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<tr>
<td></td>
<td>and impart these to their pupils.</td>
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<td>- They learn the skills of the teaching trade.</td>
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<td>- They practise finding the balance between instruction and openness</td>
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<tr>
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<td>so that pupils can and, indeed, must make their own cognitive</td>
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<tr>
<td></td>
<td>contribution.</td>
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<tr>
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<td>- They learn to assess pupils' work.</td>
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<tr>
<td></td>
<td>- Together with the teacher in charge of their teacher training,</td>
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<td></td>
<td>the students constantly evaluate their own performance.</td>
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</tr>
<tr>
<td>Content</td>
<td>The Studierenden sammeln Erfahrungen in der Unterrichtsführung, der</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Auseinandersetzung mit Lernenden, der Klassenbetreuung und der</td>
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</tr>
<tr>
<td></td>
<td>Leistungsbeurteilung. Zu Beginn des Praktikums plant die Praktikum</td>
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</tr>
<tr>
<td></td>
<td>lehrperson gemeinsam mit dem/der Studierenden das Praktikum und die</td>
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<td></td>
<td>Arbeitsaufträge. Die schriftlich dokumentierten Ergebnisse der</td>
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<td></td>
<td>Arbeitsaufträge sind Bestandteil des Portfolios der Studierenden.</td>
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<td></td>
<td>Anlässlich der Hospitationen erläutert die Praktikumlehrperson ihre</td>
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<td></td>
<td>fachlichen, fachdidaktischen und pädagogischen Überlegungen, auf deren</td>
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<td></td>
<td>Basis sie den Unterricht geplant hat und tauscht sich mit dem/der</td>
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<td></td>
<td>Studierenden aus. Die von dem/der Studierenden gehaltenen Lektionen</td>
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<td>werden vor- und nachbesprochen.</td>
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<td></td>
<td>Die Themen für die beiden Prüfungselektronen am Schluss des Praktikums</td>
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<td></td>
<td>erfahren die Studierenden in der Regel eine Woche vor dem Prüfungstermin.</td>
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<td></td>
<td>Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie</td>
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<td>spätestens 48 Stunden vor Beginn der Prüfungselektione auf den</td>
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<td>Prüfungsexperten ein. Die gehaltenen Lektionen werden</td>
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<td>kriteriernbasiert beurteilt. Die Beurteilung umfasst auch die</td>
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<td>schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten</td>
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<td></td>
<td>der Kandidatin über die gehaltenen Lektionen im Rahmen eines kurzen</td>
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<td></td>
<td>Kolloquiums.</td>
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<td>Lecture notes</td>
<td>Wird von der Praktikumlehrperson bestimmt.</td>
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<tr>
<td>Literature</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Alle anderen Lehrveranstaltungen des DZ (inkl. der Mentorierten Arbeit) sind erfolgreich abgeschlossen.</td>
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<tr>
<th>Number</th>
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<tr>
<td>151-1072-00L</td>
<td>Mentored Thesis in Didactics of Mechanical and Process Engineering</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>Q. Lohmeyer</td>
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<tr>
<td></td>
<td>Mechanical and Process Engineering</td>
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<tr>
<td>Abstract</td>
<td>The purpose of the mentored thesis is to bring together the findings</td>
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<td>from didactics and to expand them by incorporating specific teaching</td>
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<td>techniques and teaching methods. The thesis can be thematically</td>
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<td>aligned with the subsequent teaching internship.</td>
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<td>Objective</td>
<td>The students learn to link theoretical topics from the didactic</td>
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<td>education with practice-relevant aspects and to articulate the result</td>
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<td>in written form by means of a suitable task.</td>
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<td>Content</td>
<td>The choice of the topic and the definition of the contents takes</td>
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<td>place in agreement between the students and the mentor. The topic</td>
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<td>must be chosen in such a way that the learning objective described</td>
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<td>above can be achieved.</td>
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<td>Lecture notes</td>
<td>A short guideline is available.</td>
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<tr>
<td>Literature</td>
<td>The use of suitable literature is part of the assignment.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisite: Both didactics courses completed.</td>
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<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>227-0857-00L</td>
<td>Subject Didactics I for D-MAVT and D-ITET</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>Q. Lohmeyer, R. Büchi</td>
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<tr>
<td>Abstract</td>
<td>Didactics I focuses on teaching techniques as building blocks of</td>
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<td>typical lessons. This is done on the basis of the findings of teaching</td>
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<td>and learning research and their implementation in practice. The aim</td>
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<td>is the planning and implementation of effective teaching sequences as</td>
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<td>well as their evaluation and reflection.</td>
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</tbody>
</table>
Objective
- The students can plan, conduct and critically reflect single lessons.
- They orient themselves towards the academic goals and take into account existing knowledge, the professional environment and the ambitions of the students.
- They can apply the basic teaching principles meaningfully in their subject and suitably structure the learning phases.
- They can reduce and present complex technical content such that it is in a form suitable for the students to learn.
- They have considered examples of the common conceptual errors encountered by students.

Content
- Planning a teaching unit
- Opening a lecture
- Direct Instruction
- Embedded exercises
- Learning objectives
- Practicing teaching
- Excursion Fachhochschule

Lecture notes
Lecture materials are provided via Moodle.

Prerequisites / notice
Prerequisite: Educational science course already completed or at the same time.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Project Management

Social Competencies
- Communication
- Customer Orientation
- Leadership and Responsibility

Personal Competencies
- Critical Thinking
- Self-awareness and Self-reflection

Mechanical and Process Engineering TC - Key for Type

| O   | Compulsory       |   |     |
| W+  | Eligible for credits and recommended |   |     |
| W   | Eligible for credits       |   |     |
| E-  | Recommended, not eligible for credits |   |     |
| Z   | Courses outside the curriculum |   |     |
| Dr  | Suitable for doctorate     |   |     |

Key for Hours

| V   | lecture            |   |     |
| G   | lecture with exercise |   |     |
| U   | exercise            |   |     |
| S   | seminar             |   |     |
| K   | colloquium          |   |     |
| P   | practical/laboratory course |   |     |
| A   | independent project |   |     |
| D   | diploma thesis      |   |     |
| R   | revision course / private study |   |     |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Materials Science Bachelor

#### Bachelor Studies (Programme Regulations 2020)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0261-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>8</td>
<td>5V+3U</td>
<td>A. Steiger</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Functions: Differential and integral calculus for functions of one variable; power series. The mathematical methods are applied in a large number of examples from mechanics, physics and other areas which are basic to engineering.</td>
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<td>Objective</td>
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<tr>
<td></td>
<td>Introduction to the mathematical foundations of engineering sciences, as far as concerning differential and integral calculus in one variable.</td>
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<td></td>
<td>Lecture notes</td>
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<td></td>
<td>U. Stammbach: Analysis I/II</td>
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<td>Prerequisites</td>
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<td></td>
<td>Exercises and online quizzes are an important aspect of this course. Attempts at solving these problems will be honored with a bonus on the final grade. See &quot;Performance assessment&quot; for more information.</td>
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<td>Competencies</td>
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<td></td>
<td>Subject-specific Competencies</td>
<td>Techniques and Technologies</td>
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<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Assessed</td>
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<tr>
<td>401-0171-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>N. Hungerbühler</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Linear algebra is an indispensable tool of engineering mathematics. The course offers an introduction into the theory with many applications. The new notions are practised in the accompanying exercise classes. The course will be continued as Linear algebra II.</td>
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<td>Upon completion of this course, students will be able to recognize linear structures, and to solve corresponding problems in theory and in practice.</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Systems of linear equations, Gaussian elimination, solution space, matrices, LR decomposition, Determinants, structure of linear spaces, normed vector spaces, inner products, method of least squares, QR decomposition, introduction to MATLAB, applications</td>
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<td></td>
<td>* K. Meyberg / P. Vachenauer, Höhere Mathematik 1, Springer 2003</td>
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<td>Prerequisites</td>
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<td>Active participation in the exercises is part of this course. It is expected, that students submit 3/4 of all exercises for control.</td>
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<td>Competencies</td>
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<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td>327-0112-00L</td>
<td>Chemistry I</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>M. Niederberger</td>
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<td></td>
<td>Introduction to the basics, terms and concepts of general chemistry, their application to questions in material science and their connection to laboratory experiments and projects.</td>
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<td>Objective</td>
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<td></td>
<td>1) Students can describe the different atomic structures of metals, polymers and ceramics and derive basic material typical properties.</td>
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<td>2) Students are familiar with the concept of mole and molar mass and can perform stoichiometric calculations.</td>
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<td>3) Students are able to formulate the law of mass action and, with the help of the equilibrium constant, make statements about the position of equilibrium. They understand how a chemical equilibrium reacts to changes in concentration, pressure and temperature and how to apply Le Châtelier's principle.</td>
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<td>4) Students can define oxidation and reduction, determine oxidation numbers, assign reducing and oxidizing agents and calculate redox potentials. They can transfer the basics of redox chemistry to material science processes and applications such as corrosion or batteries.</td>
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<td>5) They can explain the terms acid and base, understand what pH means and they can perform pH calculations. They can describe the meaning of acids and bases using material science examples.</td>
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<td></td>
<td>Content</td>
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<td></td>
<td>We start the lecture with the question what chemistry has to do with material science. After that, we devote ourselves to the classification and separation of substances. In the next chapter we discuss the atomic structure and the periodic table. After the introduction to stoichiometry, the field of chemistry that deals with the amounts of substances added and formed in chemical reactions, we will cover the concept of chemical equilibrium, where we will learn about the law of mass action, equilibrium constants, solubility product, and also acid-base equilibrium. In the final block of the lecture, materials science will once again be in the focus when we discuss redox reactions, electrochemistry and corrosion as well as the influence of chemical bonding on material properties. For each chapter we will solve exercises together in class.</td>
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<td>Literature</td>
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<td>Lecture slides with references to further literature and additional exercises are available on Moodle.</td>
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<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>402-0050-00L</td>
<td>Physics I</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>D. Rupp</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>The lecture covers the basics of classical mechanics.</td>
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<td>Objective</td>
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<td></td>
<td>The aim of this lecture is to become familiar with the central concepts of classical mechanics, to test and consolidate basic concepts and physical intuition, and to be able to describe and solve problems with applications from everyday life and technology with the tools learned.</td>
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<td></td>
<td>Content</td>
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<td></td>
<td>- Inertia, equations of motion, Newton's laws, forces and system boundaries</td>
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<td>- Energy, impulse, rocket launch</td>
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<td>- Central forces, celestial mechanics</td>
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<td>- Tidal/apparent forces, resting and accelerated reference systems</td>
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<td>- Rotational motion</td>
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<td>- Basic properties of deformable bodies</td>
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<td>- Vibrations and resonance phenomena, waves</td>
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<td>Lecture notes</td>
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<td>A skript to the lecture is provided online.</td>
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<td></td>
<td>Literature</td>
<td></td>
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<tr>
<td></td>
<td>Rainer Müller, Klassische Mechanik - vom Weitsprung zum Marsflug. De Gruyter 2015</td>
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</table>
Foundations of Materials Science I

Abstract
The basic physical concepts for the description of materials are taught, partly in self-study, and applied in exercises. Basic atomistic and macroscopic concepts (e.g. phase diagrams, phase transformations, response functions) are introduced through examples. Selected topics are deepened in classroom lectures.

Objective
Students are able to
- name the basic concepts of materials science. (remember, 1)
- describe simple relations between atomic structure and macroscopic properties. (understand, 2)
- calculate basic material-specific quantities. (apply, 3)
- read and interpret phase diagrams, material characteristic (e.g. stress-strain) diagrams and Ashby plots (analyse, 4)

Content
Atomic structure
- Crystalline structure and defects
- Thermodynamics, phase diagrams and phase transformations
- Diffusion

Mechanical and thermal properties of materials

Literature
Main textbook:
William D. Callister, Jr., David G. Rethwisch
Materials Science and Engineering - An Introduction

Alternatives:
- Milton Ohring
  Engineering Materials Science
- James F. Shackelford
  Introduction to Materials Science for Engineers

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking

Additional First Year Basic Courses

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
327-0111-00L | Projects and Lab Courses I | O | 7 credits | 7P | M. B. Willeke, L. De Pietro, M. R. Dusselier, S. Morgenthaler Kobas, T.-B. Schweizer

Abstract
Practical introduction to the basics of the scientific method, materials science, physics and chemistry in the form of laboratory experiments and projects, some of which are closely related to the lectures in the first year. Important chemical and physical methods are tested, project work is practiced and the basics of working safely in the laboratory are learned.

Objective
The students
- keep a laboratory journal independently, completely and appropriately.
- can evaluate and display measurement data in a targeted manner.
- are able to write laboratory reports appropriately.
- know the communicative and rhetorical factors that are decisive for the success of an oral presentation.
- create effective presentation documents.
- know the general safety rules and disposal concepts for working in laboratories and apply them practically.
- proceed correctly in case of accidents and evacuations.
- learn practically how to fight a fire (fire protection course of the ETH).
- apply the basic knowledge in analytics, chemistry, physics and materials science acquired in the base year in a practical way.
- practice carrying out small experiments or small projects independently under supervision.

Content
In the area of scientific work: Keeping lab journals, data analysis, writing reports, presentation techniques, Test preparation and introduction to safe working and behaviour in the lab.

Lab experiments: Experiments from the fields of synthetic and analytical chemistry and experiments from the fields of physics and materials science, e.g: Mechanical/thermal properties (e.g. modulus of elasticity, fracture mechanics), thermodynamics, colloid chemistry, "particle tracking" with DLS and microscopy, surface technology, "wood, stone and metal" processing, and electrochemistry. Some practical experiments are organized as short projects (two afternoons), e.g. "Building a microscope from a webcam", etc.

In the projects: Two "reverse engineering" projects with everyday objects: Analysis of construction and materials, functioning in the overall context, life cycle of materials, alternative materials, etc.

Lecture notes
Instructions and further information on the individual experiments and projects (objectives, theory, experimental procedure, notes on evaluation) are available on the following website (-> Moodle dieser Veranstaltung).

Prerequisites / notice
Special students and auditors need a special permission from the lecturers.
**Competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

---

### Programming I

**327-0114-00L**

**O 2 credits 2G**

**L. De Pietro**

**Abstract**
This course provides an introduction to the general computer and programming concepts, which are necessary to perform numerical calculations, representations and simulations in materials science.

**Objective**
- Students independently develop programs to accomplish numerical calculations, representations and simulations.
- They analyse and understand the functionality of existing programs and can supplement or adapt them according to their requirements.
- They recognize basic computer science concepts and apply algorithmic thinking, i.e. they have the ability to solve problems systematically using developed algorithms.

**Content**
The course contains a first introduction to Python and Matlab. It contains:
- Basic programming concepts of structural programming like
  - Variables
  - Lists
  - Loops
  - Branches
  - Control structures
- Input and output
- Modular structure of programs with functions
- Flowcharts
- Numerical accuracy
- Data evaluation and presentation
  - Regression
  - Interpolation
- Curves fit
- Complexity Theory
- Sorting and searching
- Dynamic programming
- Recursion
- Graph Algorithms

**Lecture notes**
Moodle, Code Expert, ...

**Literature**
https://wiki.python.org/moin/BeginnersGuide

---

### Second Year Basic Courses

#### Examination Blocks

##### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0363-10L</td>
<td>Analysis III</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>A. Iozzi</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

**Objective**
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

**Content**
Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform
Lecture notes by Prof. Dr. Alessandra Iozzi: https://polybox.ethz.ch/index.php/s/D3K0TayQXvlpCAA


For reference/complement of the Analysis I/II courses:

Christian Blatter: Ingenieur-Analysis
https://people.math.ethz.ch/~blatter/dlp.html

Prerequisites / notice

For students in the bachelor's degree programme in mechanical engineering:

Precondition for this course unit are passed first year examination blocks A and B.

327-0316-00L Quantum Mechanics and Solid State Physics I

Abstract

Analysis and motivation for the necessity of a theory beyond classical mechanics to describe materials properties. The principles, terminology and concepts of quantum mechanics will be introduced and mathematically represented on the basis of simple problems.

Objective

Give reasons for the necessity of quantum mechanical description of matter and explain experimental observations leading to this description.

Clarification of the term quantum object.

Formulate and solve the Schrödinger equation for simple problems.

Application of the operator formalism for the calculation of observables and the interpretation of physical processes. Interpretation of the wavefunction.

Explain the solution of the hydrogen atom. Derivation of the approach to the solution in the application of symmetries and angular momentum operators.

Give reasons for the electron spin and calculate magnetic moments.

Content

Crisis of classical physics

Planck's law of radiation (cavity radiation), photoelectric effect (Einstein's light quantum hypothesis), Bohr quantisation of the atom, De Broglie hypothesis

Wave-particle dualism - wave mechanics, matter waves, double-slit experiment, comparison of classical mechanics and quantum mechanics

Introduction of the wave function, de-Broglie relation, probability

Postulates of quantum mechanics

Introduction of the Schrödinger equation, normalisation of the wave function, stationary Schrödinger equation, location and momentum space, location representation of the momentum operator

Wave packets (Gaussian bell curve), decay of wave packets, indeterminacy principle

Wave mechanics with forces

Piecewise constant potentials, particles in the potential well, potential step, probability current density, potential wall, tunnel effect, potential well

Formalism of quantum mechanics

Hilbert space, scalar product, vectors (basis), states, normalizability, completeness, eigenfunctions, rotations, operators - general definitions and properties, Expectation values, spectrum (discrete, continuous), matrix representation, Ehrenfest theorem, measurement process and collapse of the wave function

Central potential

Eigenvalue problem in spherical coordinates, limiting cases, particles in a 3D pot, symmetries, rotation and angular momentum, angular momentum operator and spherical surface functions

Hydrogen atom

Coulomb potential, radial wave function, orbitals, atomic structure

Lecture notes

in German, provided in the Moodle course together with the exercise sheets and corresponding solutions.


Prerequisites / notice

Physics I and II.

Analysis I and II.

Linear Algebra I and II.

Foundations of Probability theory from Programming II.

Fourier-Transformation from Analysis III is used, but is not a basic requirement.
The course teaches the basics and terminology of polymer synthesis. To synthesize various polymeric materials, different polymerization techniques are required. This course will introduce representative polymerization methodologies and will discuss how they operate in order to yield materials with enhanced polymeric characteristics.

Objective
1) The students will be able to recognize different polymer types and associate them with their chemical structure and properties (i.e. rubber elasticity, glass transition temperature, etc.)
2) The students will become familiar with various synthetic methods to produce polymers of different architectures and topologies
3) The students will be exposed to different characterization methods (e.g. size exclusion chromatography, mass-spectrometry, nuclear magnetic resonance) that are necessary to confirm the successful synthesis and structure of a polymer
4) The students will understand the mechanism of selected polymerization methodologies
5) The students will be introduced to state-of-the-art polymer synthesis and recent literature examples will be critically discussed

Content
- conventional chain growth polymerization, living chain growth polymerization, step growth polymerization, polymeric architectures, molecular weight determination methods, polymer properties, polymerization mechanisms, polymer characterization methods
- apply the methods and concepts presented in the lecture and communicate the results in written and oral form.
- understand the concept of X-ray diffraction as an elementary experimental technique for determining crystal structures.
- analyse simple crystal structures in terms of their symmetry.
- mathematically represent the geometry of a crystal lattice and derive and understand its symmetry.
- develop a basic understanding of the relationships between crystal structure, symmetry and physical properties of solids.
- understand the concept of X-ray diffraction as an elementary experimental technique for determining crystal structures.
- apply the methods and concepts presented in the lecture and communicate the results in written and oral form.

Literature
- L. Mandelkern “An Introduction to Macromolecules”
- J. M. G. Cowie “Polymers: Chemistry and Physics of Modern Materials”
- publications mentioned on the slides

Lecture notes
Lecture slides with references to further literature will be available on Moodle

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>327-0312-00L</td>
<td>Materials Synthesis I - Polymers</td>
<td>O</td>
<td>3</td>
<td>4</td>
<td>A. Anastasaki, D. Opris</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction into the main spectroscopic methods and their applications to gain compositional and structural information.</td>
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<tr>
<td>Objective</td>
<td>The aim of the course is to enable the students to select and apply the optimal analytical/spectroscopic methods for the identification of organic, inorganic and polymeric materials.</td>
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<tr>
<td>Content</td>
<td>Particular emphasis is given to qualitative and quantitative analysis of material composition at the atomic/molecular level by mass spectrometry, atomic absorption, vibrational and UV-vis spectroscopy, thermal analysis, nuclear magnetic resonance. The course will include lectures as well as hands-on practical sessions.</td>
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<tr>
<td>Literature</td>
<td>Lecture slides with references to further literature will be available on Moodle</td>
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<tr>
<td>Lecture notes</td>
<td>A guideline and a summary will be provided on the course website</td>
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<tr>
<td>Literature</td>
<td>L. Mandelkern “An Introduction to Macromolecules”</td>
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<td>Literature</td>
<td>J. M. G. Cowie “Polymers: Chemistry and Physics of Modern Materials”</td>
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<tr>
<td>Literature</td>
<td>publications mentioned on the slides</td>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>327-0315-00L</td>
<td>Statistical Thermodynamics</td>
<td>O</td>
<td>3</td>
<td>4</td>
<td>A. Gusev, L. Isa, R. Style</td>
</tr>
<tr>
<td>Abstract</td>
<td>Foundations and applications of equilibrium thermodynamics and statistical mechanics, supplemented by an elementary theory of transport phenomena.</td>
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<tr>
<td>Objective</td>
<td>The course provides a solid working knowledge in thermodynamics (as the appropriate language for treating a variety of problems in materials science) and in statistical mechanics (as a systematic tool to find thermodynamic potentials for specific problems)</td>
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<tr>
<td>Lecture notes</td>
<td>A guideline and a summary will be provided on the course website</td>
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<tr>
<td>Literature</td>
<td>R. Piazza, Statistical Physics, Springer International Publishing Switzerland 2017</td>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>327-0104-00L</td>
<td>Crystallography - Introduction to lattices and symmetries</td>
<td>O</td>
<td>2</td>
<td>2</td>
<td>T. Lottermoser</td>
</tr>
<tr>
<td>Abstract</td>
<td>The properties of crystals, which make up a large part of solid materials, are closely related to the symmetry of their internal structure. The objective of the crystallography lecture is to provide concepts and mathematical fundamentals of symmetry theory, structure-property relationships, and the basic principles of structure determination. Simple crystal structures will be discussed.</td>
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<tr>
<td>Objective</td>
<td>Students are able to:</td>
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<tr>
<td>- mathematically represent the geometry of a crystal lattice and derive and understand its symmetry.</td>
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<td>- apply concepts of group theory to classify crystal lattices based on their symmetry.</td>
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<td>- analyse simple crystal structures in terms of their symmetry.</td>
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<td>- develop a basic understanding of the relationships between crystal structure, symmetry and physical properties of solids.</td>
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<tr>
<td>- understand the concept of X-ray diffraction as an elementary experimental technique for determining crystal structures.</td>
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<tr>
<td>Content</td>
<td>Symmetry and crystal lattices: symmetry operations and lattices in two and three dimensions, point groups, space groups.</td>
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<tr>
<td>- Crystal structures: symmetry and typical simple crystal structures.</td>
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<tr>
<td>- Structure/property relationships: Neumann's principle; examples: piezoelectricity, ferroelectric.</td>
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<tr>
<td>Lecture notes</td>
<td>Materials characterization: diffraction techniques.</td>
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</table>
Projects and Applications

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<thead>
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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0314-00L</td>
<td>Computational Thinking Lab I</td>
<td>O</td>
<td>2</td>
<td>1G+1A</td>
<td>M. Kröger</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>You are going to address, in groups, problems that are arising or may arise in the context of remaining courses of your studies, that cannot be solved analytically or manually within reasonable amounts of time, but solved computationally with the help of a programming language and computers. Knowledge of a computing language is required.</td>
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</tbody>
</table>
| **Objective** | - Getting used to the idea that solving problems using a programming language is a dynamic process, where one can learn from errors and improve. 
- Thinking in modules that perform a task and can be tested separately. Modules are then combined to interact later on. 
- Organizing the distribution of work across a small group of students and ask questions, as soon as they arise. 
- Using existing resources if helpful to implement your ideas 
- Getting confronted with computational tasks as they may occur during scientific work |
| **Content** | - Develop ideas to solve well-defined problems using computational methods 
- Make use of collaborative tools (vscode, github) to edit, store and execute python code in groups 
- Create accompanying descriptions and resulting graphs (at github, using mark-down language) 
- Make use of internet resources or vscode to find answers to questions that arise (python command and their syntax, existing libraries, if helpful) 
- Short oral presentation of algorithms, results, possible improvements at the end of the semester |
| **Lecture notes** | There is no script for this course. Each project has its own project description at github. Information available at https://polyphys.mat.ethz.ch/education/courses/CTL-I.html and alternatively, at https://ctl.polyphys.mat.ethz.ch/ |
| **Prerequisites / notice** | - Basic knowledge of a programming language, ideally python 
- github account 
- Local installation of python and Visual Studio code (vscode) until the 2nd week of the semester. Detailed information available at https://ctl.polyphys.mat.ethz.ch/ |
| **Competencies** | Subject-specific Competencies: Concepts and Theories fostered 
Techniques and Technologies assessed 
Method-specific Competencies: Analytical Competencies assessed 
Decision-making fostered 
Media and Digital Technologies assessed 
Problem-solving fostered 
Project Management assessed 
Social Competencies: Communication assessed 
Cooperation and Teamwork assessed 
Leadership and Responsibility fostered 
Negotiation fostered 
Personal Competencies: Adaptability and Flexibility fostered 
Creative Thinking fostered 
Critical Thinking fostered 
Integrity and Work Ethics fostered |

327-0311-00L | Projects and Lab Courses III | O    | 8    | 8P       | M. B. Willeke, L. De Pietro, T.-B. Schweizer |
| **Abstract** | A project lasting one semester, with special requirements regarding choice of materials, properties, etc., concluding project presentation event. |
| **Objective** | Learn how to organize, manage, and execute a semester-long project. 
To impart basic knowledge and experimental competence using selected examples from chemistry and physics. |
| **Content** | Semester-long project, project assignment is determined at the beginning of each semester. 
Chemistry III: Synthesis of PMMA via Transesterification; PET recycling or manufacture of poly(methylmethacrylat) via radical polymerization of methylmethacrylat; 3D-printing. 
Physics I, five experiments out of: reflection spectroscopy, experiments on the field of polymers, e.g. viscoelasticity of the polymer melt (or an equivalent exp.); 2 physics experiments (out of 4) at the EMPA: e.g. X-ray florescence analysis, impedance measurements of batteries, "power to gas" or texture measurement, building a Lithium ionic battery; and further physic experiments. |
| **Lecture notes** | Notes with information for each experiment (aim of the experiment, theory, experimental procedure, data analysis) will be made available via moodle (link in mystudies). |
Competencies

Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered

Third Year Basic Courses

Individual courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0512-00L</td>
<td>Electronic, Optical and Magnetic Properties of Materials</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>P. Gambardella</td>
</tr>
</tbody>
</table>

Abstract
This course provides physical foundations to understand the response of different classes of materials to electromagnetic fields, focusing on their electrical, optical, and magnetic properties, and on the basic functioning of devices that exploit such properties. The lectures build on classical and quantum mechanical concepts to provide microscopic understanding and modelling.

Objective
Student should be able to:
- Apply fundamental concepts in solid state physics to describe and explain the behavior of different types of materials, including the ability to make semi-quantitative assertions about relevant physical quantities.
- Analyze and evaluate different models and approaches to describe specific material properties, and appreciate the pertinence of these models to real-world applications, including the ability to make numerical estimates of the relevant parameters.
- Explain the working principles of a range of devices that take advantage of the physical properties of materials, including electronic, photonic, and magnetic devices.
- Develop an appreciation for the role of solid state physics in modern society and technology, and understand the importance of continued research and development in this field for future technological advancements.

Content
Understanding the electronic properties of solids is at the heart of modern society and technology. The aim of this course is to provide fundamental physical concepts that allow one to relate the electronic structure of different types of materials to their electrical, optical, and magnetic behavior as well as the functioning of basic electronic, photonic, and magnetic devices. Beyond fundamental curiosity, such level of understanding is required in order to develop and appropriately describe new classes of materials for future technology applications. The course is divided in six parts.

PART I: The electronic structure of metals, semiconductors, and insulators
Revision of classical concepts: electric fields and currents, Ohm’s and Drude’s model of electrical conductivity, Hall effect, thermoelectric effects.
Revision of quantum mechanical concepts: Electron bands, Fermi statistics, Fermi energy and Fermi surface, density of states in k-space and as a function of energy.

PART II: Semiconductors: concepts and devices

PART III: Dielectric properties of insulators

PART IV: Interaction of electromagnetic waves with matter
The electromagnetic (EM) spectrum. Electromagnetic waves in vacuum; Energy, momentum, and angular momentum of EM waves; Sources of EM radiation; EM waves in matter. The refractive index. Transmission, Reflection, and Refraction from a microscopic point of view. Optical anisotropy, Optical activity, Dichroism. Optical properties of crystalline insulators and semiconductors, glasses, and metals.

PART V: Photonic devices
Photodiodes, photovoltaic cells, light emitting devices (LEDs), Laser diodes, displays, optical fibers.

PART VI: Magnetism

Lecture notes in English, available for download at http://www.intermag.mat.ethz.ch/education.html
Literature
C. Kittel, Introduction to Solid State Physics (Wiley, 2005), also printed in German. General text that covers many arguments from the point of view of condensed matter physics.
D. A. Neamen, Semiconductor Physics and Devices (McGraw-Hill, 2012). General treatment of semiconductor physics and devices, including both basic and more advanced topics.
Introduction to optics and light waves: E. Hecht, Optics (Lehmans);
Optoelectronic devices: D. A. Neamen (see above); Simon Sze, Physics of Semiconductor Devices (Wiley)

Prerequisites / notice
Physik I and II, Materialphysik I and II. The lecture will be given in English. The script will be available in English.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Social Competencies
- Communication: assessed

Personal Competencies
- Adaptability and Flexibility: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-direction and Self-management: fostered

327-0513-00L Mechanical Properties
Objective
The students are able to
- apply the interplay of structure and properties in the selection and development of materials.
- understand plasticity, crack growth, high temperature properties, corrosion, diffusion, environmental influences, grain growth, fatigue, fracture mechanics across material classes.
- to adjust mechanical properties in a targeted manner.
- to select and develop the optimal materials for specific application areas by understanding the temperature-dependent material properties.
- take measures to increase the service life of materials.
- understand concepts of material development and apply them to new materials.

Content
This course provides the fundamentals for understanding the mechanical properties of different classes of materials. The role played by the nano- and microstructure of the materials, how the mechanical properties are influenced by the composition or processing, as well as which methods can be used to determine material-specific mechanical parameters are examined.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Social Competencies
- Communication: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

327-0515-00L Thermal and Transport Properties
Objective
This course will introduce mass transport, heat conduction, charge transport, and flow in viscous liquids, with emphasis on their shared foundation in diffusive processes.

Content
Students will learn how to create models describing transport processes. They will solve the resulting equations both analytically and numerically. They will apply these results to design materials processes and understand real-life experiments. A key takeaway will be the ability to construct simple order-of-magnitude estimates and scaling relationships that can be applied to efficient data analysis and design.

Lecture notes
A script in English will be provided on the Moodle course website.

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Projects and Applications

### Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>327-0514-00L</td>
<td>Computational Thinking Lab II</td>
<td>O</td>
<td>3</td>
<td>1G+2A</td>
<td>M. Kröger</td>
</tr>
<tr>
<td>Abstract</td>
<td>You are going to address, in groups, problems that are arising or may arise in the context of remaining courses of your studies, that cannot be solved analytically or manually within reasonable amounts of time, but solved computationally with the help of a programming language and computers. Knowledge of a computing language is required.</td>
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<tr>
<td>Objective</td>
<td>- Getting used to the idea that solving problems using a programming language is a dynamic process, where one can learn from errors.</td>
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<tr>
<td>Content</td>
<td>- Thinking in modules that perform a task and can be tested separately. Modules are then combined to interact later on.</td>
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<td></td>
<td>- Organizing the distribution of work across a small group of students and ask questions, as soon as they arise.</td>
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<td></td>
<td>- Using existing resources if helpful to implement your ideas.</td>
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<td></td>
<td>- Getting confronted with computational tasks as they may occur during scientific work.</td>
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<td></td>
<td>- Create transparent (re-usable, using functions) and ideally efficient algorithms using python.</td>
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<td></td>
<td>- Make use of collaborative tools (vscode, github) to edit, store and execute python code in groups.</td>
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<td></td>
<td>- Create accompanying descriptions and resulting graphs (at github, using markdown language).</td>
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<td></td>
<td>- Make use of internet resources or vscode to find answers to questions that arise (python command and their syntax, existing libraries, if helpful).</td>
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<td></td>
<td>- Short oral presentation of algorithms, results, possible improvements at the end of the semester.</td>
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<tr>
<td>Lecture notes</td>
<td>Information available at <a href="https://polyphys.mat.ethz.ch/education/courses/CTL-II.html">https://polyphys.mat.ethz.ch/education/courses/CTL-II.html</a> or alternatively, at <a href="https://ctl.polyphys.mat.ethz.ch">https://ctl.polyphys.mat.ethz.ch</a></td>
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<tr>
<td>Prerequisites / notice</td>
<td>- Basic knowledge of a programming language, ideally python.</td>
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<tr>
<td></td>
<td>- github account.</td>
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<td></td>
<td>- Local installation of python and Visual Studio code (vscode) until the 2nd week of the semester. Detailed information available at <a href="https://ctl.polyphys.mat.ethz.ch/">https://ctl.polyphys.mat.ethz.ch/</a></td>
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</tbody>
</table>

### Competencies

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**

- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

### Course 327-0511-00L

**Capstone project**

- Type: O
- ECTS: 6
- Hours: 6P
- Lecturers: M. B. Willeke, J. F. Löffler

**Abstract**

Acquisition of independent scientific-technical skills; project management; organization and undertaking of experiments; interpretation, scientifically and technically correct project presentation in oral and written form.

**Objective**

Acquisition of independent scientific/technical skills; project management; organization and conducting of experiments; interpretation and scientifically/technically correct presentation of projects in oral and written form.

**Content**

Supervision by D-MATL research Groups.

**Prerequisites / notice**

- Prerequisite: Successful participation in the “Projekte & Praktika I - IV” (courses within the material science bachelor study at ETH) or comparable practical lab courses.

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### Competencies

**Subject-specific Competencies**
- Concepts and Theories fostered
- Techniques and Technologies fostered

**Method-specific Competencies**
- Analytical Competencies fostered
- Decision-making fostered
- Problem-solving fostered
- Project Management fostered

**Social Competencies**
- Communication fostered
- Cooperation and Teamwork fostered
- Negotiation fostered

**Personal Competencies**
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered

### Compensatory Courses

*Only possible after consultation with the Director of Studies.*

### Bachelor’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
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</table>

**Abstract**
Independent scientific project in a D-MATL research group. A written report will be prepared on the scientific studies carried out, as well as on the evaluation and discussion of the results.

**Objective**
To develop the capability of independently analyzing and addressing scientific problems.

### Bachelor Studies (Programme Regulations 2017)

#### Industrial Internship or Project

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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</tbody>
</table>

**Abstract**
12 weeks of industrial internship which is completed with a written report.

**Objective**
The main objective of the 12-week internship is to expose bachelor's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</tbody>
</table>

**Abstract**
Project in a research group at ETH or at an University of 12 weeks. The project is completed with a written report.

**Objective**
The main objective of the 12-week research project is to expose bachelor's students to the professional research environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

### Bachelor’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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</tbody>
</table>

**Abstract**
Independent scientific project in a D-MATL research group. A written report will be prepared on the scientific studies carried out, as well as on the evaluation and discussion of the results.

**Objective**
To develop the capability of independently analyzing and addressing scientific problems.

**Content**
Independent work on a scientific research project. The project will be carried out either for two days per week during the 6th semester or in a block within the first 6 weeks after the 6th semester.

**Prerequisites / notice**
The entire project, including preparation of the report, needs to take place within the allotted time.

### Science in Perspective

*see Science in Perspective: Type A: Enhancement of Reflection Capability*

### Language Courses

*see Science in Perspective: Language Courses ETH/UZH*

### Materials Science Bachelor - Key for Type

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td></td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

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### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
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</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
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</table>

**ECTS**
- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Materials Science Master

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>327-0505-00L</td>
<td>Surfaces and Interfaces I: Fundamentals, Analytics and Applications</td>
<td>W Dr</td>
<td>6</td>
<td>3G</td>
<td>L. Isa, M. P. Heuberger</td>
</tr>
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</table>

Abstract
This course teaches the basics of surface and interface science and technology, including surface modifications and forces. It covers various analytical techniques to study surface and interface properties, and explores phenomena of applied relevance like friction, lubrication, phoresis, and wetting where surfaces play a crucial role.

Objective
Students are able to
- describe the physical and chemical properties of surfaces and interfaces.
- analyze and compare analytical tools for surfaces.
- choose and combine appropriate surface-analytical approaches for solving problems connected to applications.
- understand and explain the importance of surfaces and interfaces in a broad range of phenomena and applications.

Content
- Introduction to surfaces and interfaces
- Structure of surfaces over different length scales: from macroscopic roughness to atomic structure
- Surface modifications
- Adsorption and adsorption models
- Surface forces
- Basic physical concepts
- Thermodynamics of surfaces and interfaces
- Measurement of intermolecular and surface forces
- Dynamics and history effects
- Surface analytics: X-ray Photoelectron Spectroscopy (XPS) – principles and modern developments
- Surface analytics: Secondary Ion Mass Spectroscopy (SIMS) and IR Spectroscopy – Principles and examples
- Atomic Force Microscopy (AFM): Principles and modes of operation
- Tribology: Adhesion, Friction and Lubrication
- Contact mechanics
  - Micro and macroscale friction
  - Boundary lubrication
  - Wetting
  - Contact angles
  - Phoretic phenomena
  - Electric double layer and electrophoresis
  - Electro-osmosis
  - Other types of phoresis
  - Case studies

Lecture notes
Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Literature

Prerequisites / notice
Chemistry:
General undergraduate chemistry including basic chemical kinetics and thermodynamics

Physics:
General undergraduate physics including basic theory of interatomic and intermolecular forces, atomic and crystalline structure of materials and their mechanical and electronic properties

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed

327-0703-00L Electron Microscopy in Material Science

Abstract
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content
This course provides a general introduction into electron- and ion- microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, focused ion-beam and atom probe microscopes are presented. Throughout the semester, various applications in materials science, solid state physics, structural biology, structural geology, and structural chemistry will be reported.

Lecture notes
will be distributed in English

Literature
Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)
This course explores the mechanisms that govern the adaptive functions of out-of-equilibrium systems in living organisms at the molecular

The learning goals of the course are to introduce the students to soft matter and its technological applications, to see how the structure

By the end of this course, students will be able to explain how natural selection optimizes biological materials at the molecular and

This course is divided into two main blocks. The first block focuses on the primary molecular adaptations of living organisms, while the second block covers the fundamental microstructural design principles present in biological materials.

In this course, we discuss engineering aspects of soft materials. First, we cover different classes of soft matter systems, e.g., suspensions, gels, emulsion and foams, and introduce scaling principles to design their structural, mechanical and functional properties. Second, we cover essential characterisation techniques to interrogate the structure-property relations in soft materials.

In this course, we discuss engineering aspects of soft materials. First, we cover different classes of soft matter systems, e.g., suspensions, gels, emulsion and foams, and introduce scaling principles to design their structural, mechanical and functional properties. Second, we cover essential characterisation techniques to interrogate the structure-property relations in soft materials.

This course is divided into two main blocks. The first block focuses on the primary molecular adaptations of living organisms, while the second block covers the fundamental microstructural design principles present in biological materials. 

- Temporal regulation in biological and bio-inspired molecular systems;
- Autonomous molecular structures and out-of-equilibrium systems;
- Molecular motion and work generation mechanisms in biological and bio-inspired systems;
- Sensing, adaptation, and communication in biological and bio-inspired material systems;

- Fundamentals of engineering in biological and bio-inspired materials;
- Replicating biological design principles in synthetic materials (structural, optical, surface properties, etc.);
- Bio-inspired design and systems (mechanical actuation and bio-inspiration in the built environment).

The course is mainly based on the references listed below. Additional references will be provided during the lectures.


Lecture notes

This course is mainly based on the references listed below. Additional references will be provided during the lectures.

Abstract

The aim is an overview of the different ordering phenomena that occur in materials: magnetic, electrical, mechanical, structural. Special emphasis is placed on a comprehensive definition of the term “ferroic”. Novel forms of order, such as multiferroicity, are of particular interest. Their exploration and the material functionalities derived from these are a central theme in our Department.

Objective

Ferromagnetism is known to humankind for 2500 years, but there are many other forms of spontaneously ordered states in nature that wait to be explored. One of these is ferroelectricity, the spontaneous electric order of a materials, which rapidly gains importance in science and technology. It is the aim of this course to learn what actually defines a state as ferroic, what forms of ordering are known or newly proposed, and what kind of materials and functionalities are related to ferroic materials. We also explore the transition from order to disorder, which is fluent and offers materials properties that are not found in the fully ordered or disordered state.

Content

The power of symmetry analysis, aspects of crystallography and group theory, definition and concept of ferroic order, Forms of ferroic order in nature, domains and domain walls, multiferroics and magnetoelectric correlations, dynamical processes and functionalities in ferroic materials, the transition from order to disorder, thermodynamics of such transitions and associated material properties, tour through the Laboratory for Multifunctional Ferroic Materials.

Lecture notes

There is no actual script because one of the main goals of this lecture is to work critically and creatively with the "unfinished knowledge" of a "hot" research field that is in continuous and rapid development. Realizing that scientific results are not eternally true, but need to be constantly challenged and revised if necessary is very important in becoming a researcher working at the forefront of science. It is an equally important goal that attendees learn to work critically and creatively with the "unfinished knowledge" of a "hot" research field that is in continuous and rapid development. It is important that attendees of the lecture form their own view of this field rather than following the filtered and biased view presented in a script.

Literature

V. K. Wadhawan, Introduction to Ferroic Materials, (Gordon and Breach 2000)


M. Fiebig, Nonlinear Optics on Ferroic Materials, (Wiley 2023)

R. R. Birss, Symmetry and Magnetism, (North Holland 1966)

Prerequisites / notice

Knowledge in the physics of materials, as provided by the ETH Zurich B.S. curriculum in Materials Science. Interdisciplinary or Physics students are also welcome. This lecture is on a "hot" research field that is in continuous and rapid development, so students are encouraged to provide continuous feedback so that the topics covered by the lecture can be constantly adopted. The lecture can only be as good as the constructive/critical feedback that is received.
In this course students will obtain an overarching view on thin film deposition techniques with a focus on epitaxial deposition processes. The main learning objectives are:

- Identification of most relevant deposition technique for a given application.
- Understanding of growth mechanism and growth modes.
- Understanding strategies for engineering the functionalities of the films using the deposition process.
- Selection of the most appropriate characterization technique.
- Understanding device concepts and fundamental limits in the technology relevant ultra-thin limit.
- Assessing the relevance of scientific literature dealing with complex oxide thin films.

A lab visit will be organized and students will participate to the design of thin films with atomic precision.

General description of the leading deposition routes including physical and chemical vapor deposition techniques (PVD and CVD) as well as so called "wet techniques" (e.g. spin coating and spray pyrolysis).

Growth modes and processes.

Part of the course discusses vacuum technologies.

Fundamental characterization techniques for application-relevant thin films as well as state of the art approaches for in situ and ex-situ determination of the structural, chemical and ferroic (ferromagnetic and ferroelectric) properties of films: (XRD for thin films, RHEED, EDX, scanning probe microscopy techniques, laser-optical characterization and many more)

Epitaxy for the advanced design and characterization of high quality thin films for energy efficient oxide electronics.

Types of ferroic order, multiferroics, multifunctional oxide materials, epitaxial strain related effects, oxide thin film based devices and examples.

Regular discussions on preselected scientific literature and mini-seminars will be organized.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Decision-making</td>
<td>Fostered</td>
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<td>Techniques and Technologies</td>
<td>Media and Digital Technologies</td>
<td>Assessed</td>
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<td>Assessed</td>
<td>Problem-solving</td>
<td>Assessed</td>
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<td>Project Management</td>
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**402-0535-00L Introduction to Magnetism**

This course tackles the fundamental question of why only a few materials exhibit magnetism in Nature. The origin of atomic magnetic moments and the key mechanisms that govern their interactions are justified starting from fundamental principles. In addition, the influence of thermal fluctuations on magnetic ordering is discussed as well as the formalism to describe magnetic resonance phenomena.

**Abstract**

By the end of this course, students will develop the ability to utilize quantum mechanics concepts to estimate the strength of atomic magnetic moments and understand their reciprocal interactions. They will gain proficiency in interpreting experimental measurements on model systems in terms of material composition and an appropriate, phenomenological spin Hamiltonian. For instance, students will be able to recognize whether the magnetic hysteresis observed in some samples arises from slow dynamics or from a phase transition. Lastly, they will be capable of interpreting the occurrence of abrupt transitions or the emergence of characteristic length scales as resulting from the interplay between competing interactions. Altogether, students will acquire the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

**Objective**

The lecture “Introduction to Magnetism” aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only a few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what “being magnetic” means is essential to address this question properly. Theoretical concepts will be applied to a few selected nano-sized magnets, which will serve as clean reference systems.

**Topics:**
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetism in solids (mechanisms producing inter-atomic exchange interaction in solids, crystal field)
- Magnetic order at finite temperatures (Ising, XY, and Heisenberg models, low-dimensional magnetism)
- Spin precession and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)

**Content**

Learning material will be made available through Moodle and through the ETH JupyterHub.

**Prerequisites / notice**

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.
### Elective Courses

The students are free to choose individually from the entire course offer of ETH Zürich on the Master level. Please consult the study administration in case of questions.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<td>2</td>
<td>4P</td>
<td>K. Kunze, S. Gerstl, F. Gramm, F. Krumeich, J. Reuteler</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Practical work on TEM, SEM, FIB and APT</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>treatment of typical problems, data analysis, writing of a report</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Application of basic electron microscopic techniques to materials science problems</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>see lecture Electron Microscopy (327-0703-00L)</td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td></td>
<td></td>
<td></td>
<td>Attendance of lecture Electron Microscopy (327-0703-00L) is recommended.</td>
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<td></td>
<td>Maximum number of participants 15, work in groups of 3 people.</td>
</tr>
<tr>
<td>327-1101-00L</td>
<td><strong>Biomineralization</strong></td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>K.-H. Ernst</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td>The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
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<td></td>
<td>Biominereralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere / evolution / taxonomy of organisms.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>Script with more than 600 pages with many illustrations will be distributed free of charge.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy &amp; Geochemistry Vol. 54, 2003</td>
</tr>
<tr>
<td>327-2103-00L</td>
<td><strong>Composites and Hybrids: From Design to Application</strong></td>
<td>W</td>
<td>5</td>
<td>3V+1U</td>
<td>F. J. Clemens, B. Weisse, A. Wünstüber</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td>Composites/hybrids are heterogeneous materials consisting of two or more bonded components, and it is possible to tailor material properties for certain applications. Typically, the components retain their structure and properties, but the properties of the composite are a combination of the properties of its components.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td>In this course you will get an inside to lightweight material with high strength, materials that are resistant against abrasion, ceramics with damage tolerance behavior, composites with bioactive, bioreabsorbable, piezoresistive and -electric properties. Enables materials scientists to design composite/hybrid materials for different applications. The course will comprise a balance of lectures, exercises and laboratory classes.</td>
</tr>
</tbody>
</table>
Introduction and basic concepts on biomedical composites and smart composites/hybrids with sensing and actuation properties; production and properties of composites reinforced with particles, whiskers, short or long fibers; selection criteria, case studies and applications, future perspectives.

1. Structural composites (polymer-, metal- and ceramic matrix composites)
   1.1. Introduction and historical background
   1.2. Components: Matrix and reinforcement materials
   1.3. Types of composites and mechanisms of reinforcement
   1.4. Production processes
   1.5. Physical and chemical properties
   1.6. Applications

2. Biomedical Composites
   2.1. Introduction and historical background
   2.2. Components: metals&alloys, natural/synthetic polymers, bioceramics
   2.3. Types of biocomposites
   2.4. Production processes
   2.5. Properties
   2.6. Applications

3. Functional Composites (Sensors and Actuators)
   3.1. Introduction and historical background
   3.2. Components: Matrix and functional filler material
   3.3. Types of composites
   3.4. Production processes
   3.5. Properties
   3.6. Applications

Lecture notes
We will work with handouts

Literature

Biocomposites, J. Paulo Davin (Ed.), De Gruyter (2014)


Bioresorbable polymers for biomedical applications – from fundamentals to translational medicine, G. Perale, J. Hilborn (Eds), Woodhead Publishing (2017)


Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscope lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Name</th>
<th>Credits</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-2126-00L</td>
<td>Microscopy Training TEM I - Introduction to TEM</td>
<td>2</td>
<td>Autumn Semester 2024</td>
</tr>
<tr>
<td>327-2127-00L</td>
<td>Sustainable Materials Management: Concepts, Methods and Principles</td>
<td>2</td>
<td>Autumn Semester 2024</td>
</tr>
<tr>
<td>327-2128-00L</td>
<td>High Resolution Transmission Electron Microscopy</td>
<td>2</td>
<td>Autumn Semester 2024</td>
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</tbody>
</table>
This advanced course on High Resolution Transmission Electron Microscopy (HRTEM) provides lectures focused on HRTEM and HRSTEM imaging principles, related data analysis and simulation and phase restoration methods.

- Learning how HRTEM and HRSTEM images are obtained.
- Learning about the aberrations affecting the resolution in TEM and STEM and the different methods to correct them.
- Learning about TEM and STEM images simulation software.
- Performing TEM and STEM image analysis (processing of TEM images and phase restoration after focal series acquisitions).

This course provides new skills to students with previous TEM experience. At the end of the course, students will know how to obtain HRSTEM images, how to analyse, process and simulate them.

Topics:
1. Introduction to HRTEM and HRSTEM
2. Considerations on (S)TEM instrumentation for high resolution imaging
3. Lectures on aberrations, aberration correction and aberration corrected images
4. HRTEM and HRSTEM simulation
5. Data analysis, phase restoration and lattice-strain analysis

- Detailed course manual
- Enri, Aberration-corrected imaging in transmission electron microscopy, 2nd ed., Imperial College Press, 2015

The hand-on trainings are to be carried-out on a real-life specimen, provided by lecturers and / by students.

- Prior TEM experience
- Prior attendance to the ScopeM TEM basic course
- Prior attendance to ETH EM lectures (327-0703-00L Electron Microscopy in Material Science)

Prerequisites / notice

The main goal of this hands-on course is to provide students with fundamental understanding of underlying physical processes, experimental set-up solutions and hands-on practical experience of analytical electron microscopy (AEM) technique for microstructure characterisation, specifically Energy Dispersive X-ray Spectroscopy (EDS) and spectrum imaging (SI) technique.

The students should fulfill one or more of these prerequisites:

- Prior TEM experience
- Prior attendance to the ScopeM TEM basic course
- Prior attendance to ETH EM lectures (327-0703-00L Electron Microscopy in Material Science)

The hand-on trainings are to be carried-out on a real-life specimen, provided by lecturers and / by students.

Prerequisites / notice

The main goal of this hands-on course is to provide students with fundamental understanding of underlying physical processes, experimental set-up solutions and hands-on practical experience of analytical electron microscopy (AEM) technique for microstructure characterisation, specifically Energy Dispersive X-ray Spectroscopy (EDS) and spectrum imaging (SI) technique.
Content

Future as well as existing energy supply relies on the precise determination of the amount of the energy carrier either produced or spent. The devices used for this purpose range from simple amperemeter and its scientific pendant impedance spectrometer for electricity, and the chemical analysis of fuels and their combustion products. With the advent of renewable energy and its chemical or electro-chemical storage, there is increasing demand for advanced analysis tools as well as operando spectroscopy. The objective of the course is to introduce the physical basis of most commonly used methods, i.e., separation techniques (GC, MS), spectroscopic methods (impedance spectroscopy, UV-Vis-, IR-, Raman- spectroscopy), and scattering techniques (X-ray/photoelectron spectroscopy, neutron scattering) with focus on operando techniques. The methods are discussed within the framework of current scientific questions in renewable energy research such as the analysis of reaction mechanisms in thermo- and electro-catalysis and the in-situ characterization of new energy materials with particular focus on surface phenomena and gas-solid interactions.

The course will build on the Bachelor's degree courses Analytical Chemistry and Materials Characterization Methods.

327-2137-00L Scattering Techniques for Material Characterization

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2V+1U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not take place this semester. All enrolled students are initially placed on the &quot;waiting list&quot; until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.</td>
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</table>

Abstract

The lecture presents the currently most efficient experimental techniques for microstructure material characterization: X-ray diffraction (XRD) and transmission electron microscopy (TEM). The theoretical basics, instrumentation, complementarity and exclusivity of both techniques will be taught. The course includes practical elements and examples of current research projects at D-MATL.

Objective

Students are able to do:
- systematically characterise the microstructure and phases of a given material with X-rays and electrons
- select the right tool (source, instrument, measurement strategy) and design a workflow for solving a microstructure or phase analysis problem
- comprehensively store experimentally collected data in a repository following modern data management rules such that data can be evaluated by students not involved in the experiment
- qualitatively and quantitatively evaluate and present experimental data and results collected by others

Content

The main objective of this hands-on practical course is to give students a comprehensive insight into the most important aspects of microstructure characterization using electron and X-ray scattering. The focus is on the complementarity and exclusivity of the two techniques. We will introduce the most important experimental characterization tasks, present the relevant physical and crystallographic fundamentals, and discuss how the tasks can be solved with electron and X-ray scattering. We will discuss intrinsic and extrinsic advantages and limitations of the methods and explain essential instrumentation requirements specific to each setup. Another essential facet of the course is the link to everyday D-MATL project problems presented by the lecturers or researchers from D-MATL. The lecture is accompanied by hands-on experiments on samples of D-MATL projects using state-of-the-art instruments.

- Crystallography, X-ray diffraction and electron microscopy on the BSc level. All enrolled students are initially placed on the "waiting list" until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making

Method-specific Competencies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Literature

- Crystallography, X-ray diffraction and electron microscopy on the BSc level. All enrolled students are initially placed on the "waiting list" until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.

327-2140-00L Focused Ion Beam and Applications

<table>
<thead>
<tr>
<th>W Dr</th>
<th>1 credit</th>
<th>2P</th>
</tr>
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<tbody>
<tr>
<td>Number of participants limited to 6. PhD students will be asked for a fee.</td>
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</tbody>
</table>

Abstract

The course on Focused Ion Beam (FIB) provides theoretical and hands-on learning, applying what is learned in lectures to hands-on sessions.

Objective

Overview of FIB theory, instrumentation. FIB hardware operation and applications. Set-up, align and operate a FIB-SEM successfully and safely. Accomplish operational tasks (milling and deposition) and optimize microscope parameters. Perform cross-sections: preparation and analysis Understanding of workflow for sample preparation (TEM lamella, APT needles, XCT pillars…) using FIB-SEM. Applying FIB-SEM for materials characterization.

https://scopem.ethz.ch/education/MTP.html

Registration form:
https://docs.google.com/forms/d/1GXvsZc6nTdGdH4xZyPbKlsOcdJQakYcD9yYNzGD80/edit

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1839 of 2667
This course provides FIB techniques to students with previous SEM experience. At the end of the course, students will be able to set-up a FIB-SEM session and characterize cross-sections. Students will also understand how to prepare TEM & APT samples and design a FIB experiment to solve research problems.

Introduction to FIB theory and instrumentation.
Discussion of FIB operation and applications.
Lecture and demonstration on FIB automation.
Practicals on FIB-SEM set-up and alignment.
Practicals on cross-section and site-specific sample characterization.
Practicals on sample preparation (TEM lamella/APT needles).

Lecture notes: Lecture notes will be distributed.

Literature

Prerequisites / notice
The students should fulfill one or more of these prerequisites:
- Prior attendance to the ScopEM Microscopy Training SEM I: Introduction to SEM (327-2125-00L)
- Prior SEM experience.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-2144-00L</td>
<td>Microscopy Training Cryogenic Electron Microscopy</td>
<td>1 credit</td>
<td>2P</td>
</tr>
</tbody>
</table>

Abstract
The introductory course on cryogenic electron microscopy (cryoEM) provides theoretical and hands-on learning for new operators, utilizing lectures, demonstrations and hands-on sessions.

Objective
- Overview of cryoEM theory, instrumentation, operation and applications
- Prepare cryoEM sample (vitrification using Vitrobot)
- Set-up, align and operate a cryoTEM successfully and safely
- Set up automated data collection
- Basic processing steps to analyze/interpret the data e.g., reconstruction 3D volumes

Content
This course introduces and gives an overview of cryoEM and its applications. At the end of the course, students will be familiar with how to prepare vitrified probe and how to use a cryoTEM to collect and analyze data for exemplary techniques:
- Introduction and discussion on cryoEM and instrumentation
- Lectures on cryoEM theory
- Lectures on cryoEM applications
- Practical demonstration on cryoEM grid preparation
- Practical demonstration on data collection
- Lecture and practicals/demonstration on reconstruction of 3D volumes from 2D cryoEM projections/images

Literature
- Course slides
- EM-University: (https://em-learning.com/)
- Book: CryoEM Methods and Protocols edited by T Gonen, B B Nannenga

Prerequisites / notice
The students should fulfill one or more of these prerequisites:
- Prior attendance to the ScopEM Microscopy Training SEM I
- Prior TEM experience

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-2145-00L</td>
<td>Advanced Polymer Synthesis</td>
<td>4 credits</td>
<td>3G</td>
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</tbody>
</table>

Abstract
Modern polymer synthesis (based on recent development of new organic reactions) is discussed to enable students to develop synthesis schemes for certain target structures. Both chain (ionic, coordination, ROMP, radical, catalyst-transfer) and step-growth polymerizations (transition metal catalysis) including how to achieve living polymerization or improve selectivity will be discussed.

Objective
Students should be able to:
- Identify important polymerization procedures and types of polymerization
- Predict reactivities of monomers based on the chemical structures
- Devise synthetic pathways to produce a given polymer structure
- Evaluate properties of macromolecules based on structure and synthesis method
- Develop synthesis schemes for target structures and discuss potential applications of polymers

Content
Polymerization is series of continuous organic transformation and connects small molecules. The course will give an overview of the following important polymerization procedures:
- Modern Step-growth polymerization
- Living Anionic polymerization
- Group transfer polymerization (GTP)
- Controlled cationic polymerization
- Controlled radical polymerization
- Coordination polymerization: Ziegler-Natta and Metallocene catalysts
- Olefin metathesis polymerization: ROMP, ADMET and cyclopolymerization
- Synthesis of conjugated polymers based on transition metal catalysis
- Complex macromolecules including brush and dendronized polymers

Students will learn how to deal with chemical structures and reactivities, and be able to suggest reasonable synthetic pathways to a given polymer structure, like conjugated polymers based on transition metal catalysis or complex macromolecules including brush and dendronized polymers. Aspects like controlling molar masses and structure perfection play a role throughout. The course provides students with a high-level overview of modern methods of polymer synthesis both in theoretical and practical aspects. It should enable them to develop reasonable synthesis schemes for certain target structures and also to predict the properties of given macromolecules. For all polymers presented, potential or real applications will be discussed.

Lecture notes
They will be uploaded on Moodle

Literature
Lecture notes will be given

Prerequisites / notice
Strong basic knowledge of Organic Chemistry. Any course on Introductory Polymer Chemistry such as "Advanced Building Blocks for Soft Materials" or "Introduction to Macromolecular Chemistry" or equivalent (bachelor level is also sufficient). Please discuss with the lecturer if one is not certain about the prerequisites.
Communication

Fabrication and Characterisation of Magnetic Films

Subject-specific Competencies

A. Hrabec

This block course takes place at the campus of the Paul Scherrer Institute on the premises of Laboratory for Mesoscopic Systems. The

- Creative Thinking

Each year, we extract and process a staggering amount of resources from the Earth and biosphere to cover our needs and appetite for housing, energy, transport, nutrition, technology and consumer goods. In this course, we investigate the material cycles primarily from a technical and scientific perspective (geoscience & biosphere, process engineering, material science).

- Fostered

The goal of this course is to provide the participants with a full overview of the fabrication and characterization of magnetic films and magnetic devices. The specific objectives are as follows:

1. Participants will gain a comprehensive understanding and a hands-on experience of the processes involved in fabricating magnetic materials and devices.
2. Participants will be able to explain the application areas of magnetic films and devices, including their role in fundamental research, data storage, and computation technologies.
3. Participants will develop skills in evaluating and present the suitability of different fabrication techniques for specific applications of magnetic materials.
4. Participants will be able to assess and present the potential impact of advancements in magnetic materials and devices on future technological developments in areas such as data storage and computation.

- Day 1: Making metallic and oxide films: sputtering and pulsed laser deposition techniques.
- Day 2: Superconducting Quantum Interference Device - Vibrating Sample Magnetometer (SQUID-VSM) measurements and x-ray diffractometry (XRD)
- Day 3: Optical techniques: NanoMOKE (magneto-optical Kerr effect) magnetometry, Kerr microscopy
- Day 4: Magnetic force microscopy (MFM), ferromagnetic resonance (FMR)
- Day 5: Complementary methods: synchrotron x-ray imaging (PEEM, STXM, tomography), Lorentz transmission electron microscopy (LTEM)

Limited number of participants.

Students signing up should have a strong interest in both the natural and man-made world around them.

- Independently research a specific raw material and compile a summary of its cycle and value chain.
- Evaluate whether there are alternatives to digging things up from the ground and plan (or decide) with recycling and sustainability in mind.
- Answer the question where the world's raw materials come from within the earth and biosphere.
- Fostered

Objective

At the end of the course, the students should have a qualitative and quantitative understanding of where most of the materials around them come from, how they were processed, how they got to where they are used, and what happens to them after use. The students should be able to:

- Explain how these resources are mined and how the commodities are extracted from the ore.
- Fostered

Content

The earth from a materials' perspective
- Phosphor and nitrogen – how we feed 8 billion people
- Biological resources
- Copper keeps the light on
- Radioactivity
- Student presentations on selected topics
- Sand, gravel and limestone – how we build infrastructure
- Iron versus Aluminum
- Rare earth elements – when demand and supply do not match
- Lithium gold rush
- Noble metals – small volume, big business
- Raw materials – how geopolitics, industry, and activists shape policy
- Gemstones & curiosities
- Lecture notes & presentations will be provided in electronic format.

Lecture notes

Prerequisites / notice

Students signing up should have a strong interest in both the natural and man-made world around them.

327-2146-00L

Raw Materials: From Earth to Consumer (and back)

W 3 credits 2V W. J. Malfait

Abstract

This block course takes place at the campus of the Paul Scherrer Institute on the premises of Laboratory for Mesoscopic Systems. The program consists of brief introductory lectures to the fabrication and characterization of thin magnetic films, which will be followed by hands-on sessions.

Limited number of participants. Students in waiting list will receive confirmation of attendance in the end of December.

Objective

The goal of this course is to provide the participants with a full overview of the fabrication and characterization of magnetic films and magnetic devices. The specific objectives are as follows:

1. Participants will gain a comprehensive understanding and a hands-on experience of the processes involved in fabricating magnetic materials and devices. 
2. Participants will be able to explain the application areas of magnetic films and devices, including their role in fundamental research, data storage, and computation technologies.
3. Participants will develop skills in evaluating and present the suitability of different fabrication techniques for specific applications of magnetic materials.
4. Participants will be able to assess and present the potential impact of advancements in magnetic materials and devices on future technological developments in areas such as data storage and computation.

Content

The course takes place at the campus of the Paul Scherrer Institute in the Laboratory for Mesoscopic Systems. The morning consists of introductory lectures on the use of specific fabrication and characterization techniques, which are listed below. In the afternoon, the participants will carry out hands-on experiments, where they will have a chance to step through the multifaceted chain of magnetic film development. At the end of the week, the students will be required to give a presentation about the fabrication techniques presented in the course and of the results they obtained with their experiments in relation to future applications.

- Phosphor and nitrogen – how we feed 8 billion people
- Biological resources
- Copper keeps the light on
- Radioactivity
- Student presentations on selected topics
- Sand, gravel and limestone – how we build infrastructure
- Iron versus Aluminum
- Rare earth elements – when demand and supply do not match
- Lithium gold rush
- Noble metals – small volume, big business
- Raw materials – how geopolitics, industry, and activists shape policy
- Gemstones & curiosities

Lecture notes

Prerequisites / notice

Students signing up should have a strong interest in both the natural and man-made world around them.

- Independently research a specific raw material and compile a summary of its cycle and value chain.
- Evaluate whether there are alternatives to digging things up from the ground and plan (or decide) with recycling and sustainability in mind.
- Answer the question where the world's raw materials come from within the earth and biosphere.

327-2148-00L Fabrication and Characterisation of Magnetic Films

W 2 credits 3G A. Hrabec, L. Heyderman, V. Scagnoli

Limited number of participants. Students in waiting list will receive confirmation of attendance in the end of December.

Abstract

This block course takes place at the campus of the Paul Scherrer Institute on the premises of Laboratory for Mesoscopic Systems. The program consists of brief introductory lectures to the fabrication and characterization of thin magnetic films, which will be followed by hands-on sessions.

Objective

The goal of this course is to provide the participants with a full overview of the fabrication and characterization of magnetic films and magnetic devices. The specific objectives are as follows:

1. Participants will gain a comprehensive understanding and a hands-on experience of the processes involved in fabricating magnetic materials and devices. 
2. Participants will be able to explain the application areas of magnetic films and devices, including their role in fundamental research, data storage, and computation technologies.
3. Participants will develop skills in evaluating and present the suitability of different fabrication techniques for specific applications of magnetic materials.
4. Participants will be able to assess and present the potential impact of advancements in magnetic materials and devices on future technological developments in areas such as data storage and computation.

Content

The course takes place at the campus of the Paul Scherrer Institute in the Laboratory for Mesoscopic Systems. The morning consists of introductory lectures on the use of specific fabrication and characterization techniques, which are listed below. In the afternoon, the participants will carry out hands-on experiments, where they will have a chance to step through the multifaceted chain of magnetic film development. At the end of the week, the students will be required to give a presentation about the fabrication techniques presented in the course and of the results they obtained with their experiments in relation to future applications.

- Phosphor and nitrogen – how we feed 8 billion people
- Biological resources
- Copper keeps the light on
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- Rare earth elements – when demand and supply do not match
- Lithium gold rush
- Noble metals – small volume, big business
- Raw materials – how geopolitics, industry, and activists shape policy
- Gemstones & curiosities

Lecture notes

Prerequisites / notice

Students signing up should have a strong interest in both the natural and man-made world around them.

- Independently research a specific raw material and compile a summary of its cycle and value chain.
- Evaluate whether there are alternatives to digging things up from the ground and plan (or decide) with recycling and sustainability in mind.
- Answer the question where the world's raw materials come from within the earth and biosphere.

Literature

- Jens Als-Nielsen and Des McMorrow, Elements of Modern X-ray Physics, Wiley
- https://www.youtube.com/watch?v=sdrr12kkdO8&ab_channel=QuantumDesignUSA
This course offers a hands-on introduction to robotic materials with a focus on the material-centric approach to create devices and robots with soft materials. Throughout the course, parallel lectures and labs will introduce soft materials and mechanisms for soft actuators, sensors, and systems for robotic and biomedical applications. Project-based labs will work towards a final robotic challenge.

### Abstract
By the end of the course, students will be able to learn the soft material library and collection of mechanisms to build soft functional devices, ranging from actuators, sensors, to integrated systems. Students will develop an understanding of material selection and development, as well as be able to evaluate the pros and cons of various mechanisms for different robotic and biomedical applications. Through the project-based lab sessions in parallel to the lectures, students will acquire the ability to design, fabricate, characterize, and integrate various soft functional devices (e.g., wearable sensors, grippers, mobile robots, etc.). A final soft robotic challenge (group project) will test the performance of the integrated system for a medical application.

### Content
- **Soft material library for functional devices**
  - intrinsically soft materials
  - hybrid materials approach with extrinsically soft structures
- **Actuating mechanisms with soft materials**
  - Lecture: fluidic elastomer actuator, electroactive polymer actuator, stimuli-responsive actuator
  - Lab: design, fabrication, and characterization of soft actuators for steering, gripping, and locomotion
- **Sensing mechanisms with soft materials**
  - Lecture: resistive, capacitive, and optoelectronic soft sensors
  - Lab: design, fabrication, and characterization of soft sensors as wearable devices
- **Sustainable soft devices and robots**
  - Lecture: natural and synthetic soft materials, devices, and robots that can self-heal, biodegrade, and recycle
  - Medical soft robotics
    - Lecture: overview of soft bioelectronic devices, review of current soft robotic technologies in medical applications
    - Lab: final project on design, fabrication, and testing of a soft robotic instrument for a medical application.

### Literature

Stretchable W

**Handouts will be provided for each lecture.**

### Prerequisites
- Basic knowledge in material properties, circuits, and polymers covered at the bachelor level required. (courses: Physics 2, Mechanics, Bioelectronics for Medical Devices and Systems, John A. Rogers, Roozbeh Ghaffari, Dae-Hyeong Kim. ISBN: 978-3-319-28694-5

### Competencies
- Subject-specific Competencies
- Techniques and Technologies
- Decision-making
- Problem-solving
- Creative Thinking
- Critical Thinking
- fostered
- assessed

### Table of Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
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<tbody>
<tr>
<td>327-2149-00L</td>
<td>Robotic Materials</td>
<td>W 4 credits 2G+2P</td>
<td>H. Bai</td>
<td>Does not take place this semester.</td>
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<tr>
<td>101-0617-01L</td>
<td>Advances in Building Materials</td>
<td>W 4 credits</td>
<td>R. J. Flatt, I. Burgert</td>
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<tr>
<td>101-0677-00L</td>
<td>Concrete Technology</td>
<td>W 2 credits</td>
<td>F. Nägele, G. Martinola, T. Wangler</td>
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</table>

### Content
- Opportunities and limitations of concrete technology.
- Commodities and leading edge specialties.

### Objective
- Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.
Content

Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as: self compacting concrete, fiber reinforced concrete, fast setting concrete
- the role of sustainability in concrete technology
- new research in digital fabrication with concrete

Lecture notes

Slides provided for download.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed

151-0353-00L Mechanics of Composite Materials W 4 credits 2V+1U G. Pappas

Abstract

The course treats aspects related to elastic behavior of unidirectional and multidirectional laminates, micromechanics, failure and damage analysis, analysis and design of composite structures. The focus is on laminated fiber-reinforced polymer composites.

Objective

The objective is to introduce the basic concept of composite materials and provide a thorough understanding of the mechanical response of such materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

Content

The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics & Homogenization
- Classical Laminate Theory (CLT)
- Strength, failure and damage analysis
- Thin ply composite shells & effects of material non-linearity
- Analysis and design of composite structures

Lecture notes

Script, handouts, exercises and additional material are available in PDF-format on the moodle page of the lecture.

Literature

The lecture material is covered by a script/lecture notes compiled by CMASLab and further literature is referenced therein.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered

151-0544-00L Metal Additive Manufacturing - Mechanical Integrity and Process Simulation W 4 credits 3G E. Hosseini

Note: The previous course title until HS22 "Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis"

Abstract

An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

Objective

The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using commercial analysis tools (e.g. ABAQUS) for simulation of the MAM process.
Analytical Competencies assessed

- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (stainless steel, Ti6Al4V, Inconel 718),
- Design for additive manufacturing
- Artificial intelligence for AM

Exercise sessions use ABAQUS for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. Students can install the packages on their own systems.

Lecture notes
Handouts of the presented slides.

Literature
No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).

Prerequisites / notice
A basic knowledge of mechanical analysis, metallurgy, thermodynamics is recommended.

Competencies

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151-0550-00L Adaptive Materials for Structural Applications

Abstract
Adaptive materials offer appealing ways to extend the design space of structures by introducing time-variable properties into them. In this course, the physical working principles of selected adaptive materials are analyzed and simple models for describing their behavior are presented. Some applications are illustrated also with laboratory experiments where possible.

Objective
The study of adaptive materials covers topics that range from chemistry to theoretical mechanics.

The aim of this course is to convey knowledge about adaptive materials, their properties and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.

Content
This course will provide the students with an insight into the properties and physical phenomena which lead to the features of adaptive materials. Starting from chemomechanical (skeletal muscles), the physical behavior of a wide range of adaptive materials, thermo- and photo-mechanical, electro-mechanical, magneto-mechanical and meta-materials will be thoroughly discussed and analyzed. Up-to-date results on their performance and their implementation in mechanical structures will be detailed and studied in laboratory sessions.

Analytical tools and energy based considerations will provide the students with effective instruments for understanding adaptive materials and assess their performance when integrated in structures or when arranged in particular fashions.

Basic concepts: Power conjugated variables, dissipative effects, geometry- and materials-based energy conversion


Thermo-mechanical coupling: Shape memory alloys / polymers

Electromechanical coupling(1): DEA, EBL, electrorheological fluids

Shape control / morphing: Use, requirements, challenges

Morphing applications of variable stiffness structures: Lab work

Electromechanical coupling (2): Piezoelectric, electrostrictive effect

Vibration Reduction: Measurement, passive, semi-active (active) damping methods

Vibration reduction applications of piezoelectric materials: Lab work

Metamaterials: Definition of metamaterials - electromagnetic, acoustical and other metamaterials

Energy harvesting and sensing: Energy harvesting with EAP and piezoelectric materials, transducers as sensors: Piezo, resistive,...

Lecture notes
Lecture notes (manuscript and handouts) will be provided

Competencies

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227-0617-00L Solar Cells

Abstract
Physics, technology, characteristics and applications of photovoltaic solar cells and systems.

Objective
The students will appreciate the potential of solar radiation and photovoltaics, will learn the physics and technology of various solar cells, and will get to know the design basics of PV modules and systems for different applications.

Content
Introduction to photovoltaics and economic aspects, solar radiation, semiconductor physics and operation of solar cells, technology of wafer-based (Si, GaAs, multi-junction) and thin-film (CIGS, CdTe, perovskite) solar cells, emerging technologies, design of PV modules, systems and plants including system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples such concentrated photovoltaics and power generation for space applications.
Lecture notes: Lecture slides (PDF files in English) will be available on Moodle and lecture recordings will be available on the ETH video portal. 

Prerequisites / notice: Prerequisites: Basic knowledge of semiconductors.

Competencies: Subject-specific Competencies

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<td>227-0619-00L</td>
<td>Charge Transport in Energy Conversion and Storage Devices</td>
<td>6</td>
<td>W</td>
<td>C. Battaglia, A. Senocate</td>
</tr>
<tr>
<td>227-0621-00L</td>
<td>Emerging Memory Technologies</td>
<td>3</td>
<td>W</td>
<td>M. Yarema</td>
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<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>4</td>
<td>W</td>
<td>V. Vogel, further lecturers</td>
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</table>

Abstract:

The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolysers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in electrical engineering, materials science, physics, and chemistry.

Objective:

By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolysers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

Literature:

R. Huggins, Advanced Batteries, DOI:10.1007/9780387764245

Prerequisites / notice:

Be motivated to change the world to renewable energies!

This course is taught simultaneously at ETH Zurich and EPFL. All lectures will be recorded by zoom and made available to the students. Lectures will be streamed live from ETH Zurich with four lectures taught onsite at EPFL Lausanne.

A visit to Empa’s Energy Conversion and Storage Labs will be organized during the semester. Possibility to interact and meet your classmates from EPFL via online lecture platform and during two special lectures with guest lecturers from industry (one guest lecture by ABB at ETH Zurich, one guest lecture by Northvolt at EPFL). Travel expenses for students will be covered.

Elements of calculus will be reviewed during the lectures, where necessary, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite.

Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students.

Competencies: Subject-specific Competencies

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Abstract:

This course focuses on the current state and prospects of memory technologies, emerging beyond the silicon transistor era. We explore resistive PCM and RRAM, magnetic MRAM and ferroelectric FRAM memories, covering physics, device aspects and the latest research in the field. Through interactive lectures and laboratory sessions, students gain up-to-date knowledge and compare emerging memory techs.

In this course, students will learn about the leading contenders for post-silicon storage-class and main memory technologies. Decades of research have yielded several efficient memory device working principles, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM, MTJ), and ferroelectricity (FRAM, FeFET). Currently, these memory technologies are transitioning from research to industry, and are predicted to have at least niche applications in the ever-growing hardware market. Some technologies, such as PCM, may even eventually surpass silicon-based flash memory, providing better performance and unique features.

Students will have the opportunity to compare emerging memory technologies with state-of-the-art SSD Flash, DRAM, and SRAM, as well as evaluate their potential. Through critical thinking discussions, students will acquire important skills for assessing the strengths and limitations of these emerging technologies.

Content:

The course organized as a series of lectures, focusing on selected memory technologies. This class also includes practical laboratory sessions for the PCM research topics. Students will spend 2 hours per week in the class or laboratory and additional 2-3 hours per week to prepare for the exam.

Literature:

Lecture notes will be made available on the website.

Competencies: Subject-specific Competencies

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Abstract:

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Objective:

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content:

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.
Biocompatible Materials

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objectives
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature

(available online via ETH library)

Semiconductor Materials: Fundamentals and Fabrication

Abstract
This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objective
Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing

Content
1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
   3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
   4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. In situ characterization
6. The invention of the transistor - Christmas lecture

Lecture notes
https://moodle-app2.let.ethz.ch/course/view.php?id=23113

Prerequisites / notice
The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Communication
Self-presentation and Social Influence

Social Competencies
fostered
fostered
fostered
fostered

Nanomaterials for Photonic Devices

Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, photonic integrated circuits, ordered and disordered structures...). It starts with concepts of light-matter interactions, fabrication and characterization, the description of the properties and the state-of-the-art applications and devices.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.
1. Introduction to nanophotonics
2. Wave physics for nanophotonics
3. Characterization of nanomaterials
4. Semiconductors
5. Nonlinear crystals
6. Photonic integrated circuits
7. Optical quantum devices
8. Plasmonics
9. Metasurfaces
10. Graphene & 2D Materials
11. Nanocomposites

Lecture notes
Slides and book chapter will be available for downloading

Literature
References will be given during the lecture

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help

Competencies
Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Technologies: assessed

Method-specific Competencies
Analytical Competencies: fostered
Decision-making: fostered

Social Competencies
Communication: assessed
Cooperation and Teamwork: assessed
Leadership and Responsibility: fostered

Personal Competencies
Creative Thinking: assessed
Critical Thinking: assessed
Self-awareness and Self-reflection: fostered
Self-direction and Self-management: fostered

402-0595-00L
Semiconductor Nanostructures
W 6 credits 2V+1U T. M. Ihn

Abstract
The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

Objective
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

Content
1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

Lecture notes

Literature
In addition to the lecture notes, the following supplementary books can be recommended:

Prerequisites / notice
The lecture is suitable for all physics students, students of Quantum Engineering, and students of Micro- and Nanosystems beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitious students in the third year of Physics may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.
We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia and Python.

Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems.

Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics & kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion.

The course establishes the fundamentals to understand and describe electrochemical reactions and phenomena related to these. The students are familiarized with key concepts and approaches in electrochemistry and selected aspects of materials science and engineering and how they are put to use in selected applications.
Introduction: important quantities & units, terminology;

Chapter II - Equilibrium electrochemistry:
- cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;

Chapter III - Electrodes & interfaces:
- electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;

Chapter IV - Electrolytes:
- conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;

Chapter V - Dynamic electrochemistry:
- overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;

Chapter VI - Industrial electrochemistry:
- electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;

Chapter VII - Energy storage & conversion:
- important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;

Chapter VIII - Electroanalytical methods & sensors:
- potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;

Chapter IX - Corrosion:
- corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

Lecture notes, lecture slides, exercise & solutions (PDF files)

Prerequisites / notice
Students should be familiar with the fundamentals of physical chemistry.

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Problem-solving: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Lecture notes:
- Literature:
- Prerequisites / notice:

Content
- Fostered
- Assessed

Autumn Semester 2024

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1849 of 2667
Content
The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and requires a multi-disciplinary approach that leverages and cross-fertilizes biology, physical chemistry, biophysics, and soft matter. This course will explore the properties, functions and potential applications of biomolecular condensates, including their role in neurodegenerative diseases such as Alzheimer's and Parkinson's, as well as their use as smart biomimetic materials.

This course is divided into two parts. The first part will introduce the basic concepts essential to the study of biomolecular condensates and phase separation. Topics include: fundamental units and scales in soft matter, phase transitions in biology, biopolymers and molecular self-assembly, introduction to active matter. This will establish a foundation for the second part, which will explore milestone works and current research in the field of biomolecular condensates. Each lecture of this second part will consist of:

1) a short literature seminar, where student groups will present and discuss a milestone paper assigned in advance and
2) a research seminar, where one of the course lecturers will present their own state-of-the-art research in the field, building upon the milestone literature.

At the beginning of the course, student groups will be formed and assigned to the milestone papers. To facilitate this, students must confirm their registration by the beginning of the 3rd week of semester.

Lecture notes
Lecture slides and some scripts will be provided.

Literature
No compulsory textbooks. Literature will be provided during the course.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
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<td>Problem-solving</td>
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<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<td>Negotiation</td>
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<td>assessed</td>
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</table>

752-2314-00L Physics of Food Colloids

W 3 credits 2V P. A. Fischer, R. Mezzenga, M. Radiom

Abstract
In Physics of Food Colloids the principles of colloid science will be applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

Objective
The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Content
Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in the investigation of complex food structures (8h). Most chapters include some hands-on examples of the gain knowledge to common food products.

Lecture notes
Notes will be handed out during the lectures.

Literature
Provided in the lecture notes.

Competencies

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<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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Research Project (only for Programme Regulations 2023)

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
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<td>327-1210-10L</td>
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<td>O</td>
<td>12 credits</td>
<td>23A</td>
<td>Professors</td>
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</table>

Abstract
Independent scientific practice of 8 weeks which is completed with a written report.

Objective
Projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.

Industrial Internship (only for Programme Regulations 2023)

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<tr>
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<th>Title</th>
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<th>Lecturers</th>
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<tbody>
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<td>Industrial Internship</td>
<td>O</td>
<td>12 credits</td>
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<td>external organisers</td>
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</tbody>
</table>

Abstract
12 weeks of industrial internship which is completed with a written report.

Objective
The main objective of the 12-week internship is to expose students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.
### Projects (only for Programme Regulations 2012)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>327-1210-00L</td>
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<td>O</td>
<td>12 credits</td>
<td>23A</td>
<td>Professors</td>
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<tr>
<td></td>
<td>Only for Materials Science MSc, Programme Regulations 2012</td>
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<tr>
<td>Abstract</td>
<td>Independent scientific practice of 8 weeks which is completed with a written report.</td>
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<tr>
<td>Objective</td>
<td>Projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.</td>
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<th>Lecturers</th>
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<td>327-1211-00L</td>
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<td>12 credits</td>
<td>23A</td>
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<td></td>
<td>Only for Materials Science MSc, Programme Regulations 2012</td>
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### Master's Thesis

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<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>327-9000-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
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<tr>
<td></td>
<td>Only students who fulfill the following criteria are allowed to begin with their master thesis: a. successful completion of the bachelor programme; b. fulfilling of any additional requirements necessary to gain admission to the master programme.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Independent scientific work of current topics in the field of materials science. Duration 6 months. The work is documented in a written form.</td>
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<tr>
<td>Objective</td>
<td>Master thesis is a six month fulltime project and will encourage the students to work independently and in a structured and scientific way. It is guided by a professor of the Department of Materials.</td>
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</tbody>
</table>

### Science in Perspective

- see Science in Perspective: Language Courses ETH/UZH
- see Science in Perspective: Type A: Enhancement of Reflection Capability

**Recommended Science in Perspective (Type B) for D-MATL**

### Materials Science Master - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
<th>Z</th>
<th>Courses outside the curriculum</th>
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<tbody>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Mathematics (General Courses)

#### Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>A. Bandeira, S. Mishra, R. Pandharipande, University lecturers</td>
</tr>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>N. Hungerbühler, M. Akveld, D. Grawehr Morath, D. Komm, P. Spindler</td>
</tr>
</tbody>
</table>

**Abstract**

**Didactics colloquium**

**Actuary SAA Education at ETH Zurich**

Further pieces of information are available at Prof. M. Wüthrich’s secretariat, HG F 42.

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>401-3925-00L</td>
<td>Non-Life Insurance: Mathematics and Statistics</td>
<td>W</td>
<td>8 credits</td>
<td>4V+1U</td>
<td>M. V. Wüthrich</td>
</tr>
</tbody>
</table>

**Abstract**

The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.

**Objective**

The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.

**Content**

The following topics are treated:

- Collective Risk Modeling
- Claim Counts Models
- Individual Claim Size Modeling
- Censoring and Truncation
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tariffication
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

**Lecture notes**

M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics

http://ssrn.com/abstract=2319328

**Literature**

M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications


**Prerequisites / notice**

The exams ONLY take place during the official ETH examination period (no semester end exams), and only in person exams (i.e. no remote exams).

This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

**Prerequisites:** knowledge of probability theory, statistics and applied stochastic processes.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
  - Decision-making assessed
  - Media and Digital Technologies fostered
  - Problem-solving assessed
  - Project Management fostered

**401-3922-00L**

**Life Insurance Mathematics**

| W    | 4 credits | 2V   | M. Koller          |

**Abstract**

The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

**401-3929-00L**

**Financial Risk Management in Social and Pension Insurance**

| W    | 4 credits | 2V   | P. Blum            |

**Abstract**

Investment returns are an important source of funding for social and pension insurance, and financial risk is an important threat to stability. We study short-term and long-term financial risk and its interplay with other risk factors, and we develop methods for the measurement and management of financial risk and return in an asset/liability context with the goal of assuring sustainable funding.
In life insurance, it is essential to have adequate mortality rates, be it for reserving or pricing purposes. The course provides the classical

Extensive handouts will be provided. Moreover, practical examples and data sets in Excel will be made available.

Understand and be able to carry out portfolio construction: the concept of diversification; limitations to diversification; correlation breakdown; incorporation of constraints; sensitivities and shortcomings of optimized portfolios.

Understand and interpret the asset-liability interplay: the optimized portfolio in the asset-liability framework; short-term risk vs. long-term risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Have an overall view: see the big picture of what asset returns can and cannot contribute to social security; be aware of the most relevant outcomes; know the role of the actuary in the financial risk management process.

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of

1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

Solid base knowledge of probability and statistics is indispensable. Specialized concepts from financial and insurance mathematics as well as quantitative risk management will be introduced in the lecture as needed, but some prior knowledge in some of these areas would be an advantage.

This course counts towards the diploma of "Aktuar SAV".

The exams ONLY take place during the official ETH examination period.

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401-3927-00L Mathematical Modelling in Life Insurance W 4 credits 2V T. J. Peter

Abstract

In life insurance, it is essential to have adequate mortality rates, be it for reserving or pricing purposes. The course provides the classical tools necessary to create mortality tables from scratch as well as modern machine learning approaches to forecast mortality rates. It also covers the basics of survival analysis.

Objective

The course's objective is to provide the students with the understanding and the tools to create mortality tables on their own. Additionally, students should learn the basics of survival analysis.
Following main topics are covered:

- Determining raw mortality rates
- Smoothing techniques
- Trends in mortality rates
- Integration of safety margins
- Stochastic mortality model due to Lee and Carter
- Neural network extension of the Lee-Carter model
- Machine learning for mortality forecasts
- Survival analysis

Lectures notes

Lectures notes and slides will be provided

Prerequisites / notice

The exams ONLY take place during the official ETH examination period.

The course counts towards the diploma of "Aktuar SAV".

Basic knowledge in probability theory is assumed. Some knowledge in financial mathematics is useful.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Problem-solving: assessed

401-3913-01L Mathematical Foundations for Finance

Abstract
First introduction to main modelling ideas and mathematical tools from mathematical finance

Objective
This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Content
Topics to be covered include
- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

Lecture notes
See information on course homepage

Prerequisites / notice
Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitstheorie").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed

363-0565-00L Principles of Macroeconomics

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course Moodle page contains announcements, course information and lecture slides.

Literature

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

### Objective
The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

### Content
- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

### Prerequisites
This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

### Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: fostered
  - Media and Digital Technologies: fostered
  - Problem-solving: assessed
  - Project Management: fostered
- Social Competencies
  - Communication: fostered
  - Cooperation and Teamwork: fostered
  - Customer Orientation: fostered
  - Leadership and Responsibility: fostered
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: fostered
  - Negotiation: fostered
- Personal Competencies
  - Adaptability and Flexibility: fostered
  - Creative Thinking: fostered
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

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The course covers the economics of risk and insurance, in particular the following topics will be discussed:

1) individual decision making under risk
2) models of insurance demand, risk sharing, insurance supply
3) information issues in insurance markets
4) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

### Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model’s underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we’ll explore how behavioural economics can be leveraged by the insurance industry.

### Literature
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1

Further readings:

### Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: assessed
- Personal Competencies
  - Critical Thinking: assessed
  - Self-direction and Self-management: fostered

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1855 of 2667
### Mathematics (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Key for Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>V: lecture</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>G: lecture with exercise</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>U: exercise</td>
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<tr>
<td></td>
<td></td>
<td>S: seminar</td>
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<tr>
<td></td>
<td></td>
<td>K: colloquium</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>P: practical/laboratory course</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>A: independent project</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>D: diploma thesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R: revision course / private study</td>
</tr>
</tbody>
</table>

### Key for Hours

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium
- **P**: practical/laboratory course
- **A**: independent project
- **D**: diploma thesis
- **R**: revision course / private study

### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
First Year Compulsory Courses

First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10</td>
<td>6V+3U</td>
<td>L. Kobel-Keller</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<tr>
<td></td>
<td>Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>The ability to work with the basics of calculus in a mathematically rigorous way.</td>
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<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>H. Amann, J. Escher: Analysis I</td>
<td></td>
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<td></td>
<td>J. Appell: Analysis in Beispielen und Gegenbeispielen</td>
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<tr>
<td></td>
<td>R. Courant: Vorlesungen über Differential- und Integralrechnung</td>
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<tr>
<td></td>
<td>O. Forster: Analysis I</td>
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<td></td>
<td>H. Heuser: Lehrbuch der Analysis</td>
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<tr>
<td></td>
<td>K. Königsberger: Analysis I</td>
<td></td>
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<tr>
<td></td>
<td>W. Walter: Analysis I</td>
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<tr>
<td></td>
<td>V. Zorich: Mathematical Analysis I (englisch)</td>
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<tr>
<td></td>
<td>A. Beutelspacher: &quot;Das ist o.B.d.A. trivial&quot;</td>
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<td></td>
<td>H. Schichl, R. Steinbauer: Einführung in das mathematische Arbeiten</td>
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<table>
<thead>
<tr>
<th>402-1701-00L</th>
<th>Physics I</th>
<th>O</th>
<th>7</th>
<th>4V+2U</th>
<th>K. Ensslin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course gives a first introduction to Physics with an emphasis on classical mechanics.</td>
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<tr>
<td>Objective</td>
<td>Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.</td>
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</table>

<table>
<thead>
<tr>
<th>252-0847-00L</th>
<th>Computer Science</th>
<th>O</th>
<th>5</th>
<th>2V+2U</th>
<th>M. Fischer, F. Friedrich Wicker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens &quot;behind the scenes&quot; when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.</td>
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<tr>
<td>Content</td>
<td>The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture slides and all other material will be made available for download on the course web page.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Bjørne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison–Wesley, 2000</td>
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First Year Examination Block 2

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<tr>
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<th>Hours</th>
<th>Lecturer</th>
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<tbody>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>S. Zerbes</td>
</tr>
<tr>
<td>Objective</td>
<td>- Mastering basic concepts of Linear Algebra</td>
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<tr>
<td></td>
<td>- Introduction to mathematical methods</td>
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</tbody>
</table>
Bachelor Studies (Programme Regulations 2021)

Compulsory Courses

<table>
<thead>
<tr>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>Ö. Imamoglu</td>
</tr>
<tr>
<td>401-2003-00L</td>
<td>Algebra I</td>
<td>O</td>
<td>7</td>
<td>3V+2U</td>
<td>L. Halbeisen</td>
</tr>
<tr>
<td>401-2653-21L</td>
<td>Numerical Analysis I</td>
<td>O</td>
<td>7</td>
<td>3V+2U</td>
<td>C. Schwab</td>
</tr>
</tbody>
</table>

Language

We will provide German lecture notes and an English translation at latest at the start of the semester.

Literature

Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester. Besides this we also recommend:


In addition we recommend this general introduction into studying mathematics:


In addition we recommend this general introduction into studying mathematics:

Bachelor Studies (Programme Regulations 2021)

Compulsory Courses

Examination Block 1

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<td>6</td>
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<td>3V+2U</td>
<td>L. Halbeisen</td>
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<td>C. Schwab</td>
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Bachelor Studies (Programme Regulations 2021)

Compulsory Courses

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<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>Ö. Imamoglu</td>
</tr>
<tr>
<td>401-2003-00L</td>
<td>Algebra I</td>
<td>O</td>
<td>7</td>
<td>3V+2U</td>
<td>L. Halbeisen</td>
</tr>
<tr>
<td>401-2653-21L</td>
<td>Numerical Analysis I</td>
<td>O</td>
<td>7</td>
<td>3V+2U</td>
<td>C. Schwab</td>
</tr>
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Language

We will provide German lecture notes and an English translation at latest at the start of the semester.

Literature

Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester. Besides this we also recommend:


In addition we recommend this general introduction into studying mathematics:
Prerequisites / notice
Admission Requirements:
Completed courses and passed written exams
Linear Algebra I, Analysis I in ETH BSc MATH
Linear Algebra II, Analysis II in ETH BSc MATH
Weekly homework assignments involving MATLAB programming
are an integral part of the course.
Turn-in of solutions will be graded.

Competencies

Subject-specific Competencies
Concepts and Theories
assessed
Techniques and Technologies
assessed

Method-specific Competencies
Analytical Competencies
assessed
Decision-making
fostered
Media and Digital Technologies
fostered
Problem-solving
assessed
Project Management
fostered

Social Competencies
Communication
fostered
Cooperation and Teamwork
fostered
Customer Orientation
fostered
Leadership and Responsibility
fostered
Self-presentation and Social Influence
fostered
Sensitivity to Diversity
fostered
Negotiation
fostered

Personal Competencies
Adaptability and Flexibility
fostered
Creative Thinking
assessed
Critical Thinking
assessed
Integrity and Work Ethics
fostered
Problem-solving
assessed
Project Management
fostered
Self-presentation and Social Influence
assessed
Sensitivity to Diversity
fostered
Negotiation
fostered

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-2283-00L</td>
<td>Analysis III (Measure Theory)</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>F. Da Lio</td>
</tr>
</tbody>
</table>

Abstract
Measure and integration theory, including: Caratheodory's theorem, Lebesgue measure, Radon measure, Hausdorff measure, convergence theorems, L^p spaces, Radon-Nikodym theorem, product measure and Fubini's theorem

Objective
Basics of abstract measure and integration theory

Content
Measure Spaces (Lebesgue Measure, Hausdorff Measure, Radon Measure)
• Measurable Functions: definition and properties
• Integration: definition, properties, theorems of convergence, Lebesgue L^p spaces
• Product Measures and Multiple Integrals. Fubini and Tonelli Theorems, Convolutions
• Differentiation of measures (if time permits)

Lecture notes
Die Vorlesung folgt dem Skript von der Dozentin
(https://people.math.ethz.ch/~fdalio/Measuremainfile.pdf)

Literature
1. Lecture notes by Professor Michael Struwe (http://www.math.ethz.ch/~struwe/Skripten/AnalysisIII-SS2007-18-4-08.pdf)
2. L. Evans and R.F. Gariepy "Measure theory and fine properties of functions"
3. Walter Rudin "Real and complex analysis"
4. R. Bartle The elements of Integration and Lebesgue Measure
http://www.mat.uniroma2.it/~cannarsa/cam_0607.pdf

Prerequisites / notice
Analysis 1 & 2 und basic notions of topology

Minor Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>402-2883-00L</td>
<td>Physics III</td>
<td>W</td>
<td>7</td>
<td>4V+2U</td>
<td>S. Johnson</td>
</tr>
</tbody>
</table>

Abstract
Introductory course on quantum and atomic physics including optics and statistical physics.

Objective
A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.

Content
Einführung in die Quantenphysik: Planck'sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrsche Atombahnen, de-Broglie Materiewellen.
Optik-Wellenoptik: Linsen, Abbildungssysteme, Brechung und Fermatsches Prinzip, Beugung, Interferenz, Fabry-Perot, Interferometer, Spektrometer.
Quantenmechanik: Dualismus Teilchen-Welle, Wellenfunktionen, Operatoren, Schrödinger-Gleichung, Potentialstufe und Potentialkasten, harmonischer Oszillator
### 402-2203-01L

**Classical Mechanics**

**Abstract**
A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

**Objective**
Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Problem-solving

**Literature**
M. Alonso, E. J. Finn
Quantengesetze und Statistische Physik
R. Oldenbourg Verlag, München
5. Auflage
ISBN 978-3-486-71340-4

**Prerequisites**
Bachelor Studies (Programme Regulations 2016)

**ECTS**
7 credits

**Lecture notes**
Im Rahmen der Veranstaltung werden die Folien in elektronischer Form zur Verfügung gestellt. Ergänzendes Buch wird als Pflichtlektüre empfohlen. Es wird kein Skript in der Vorlesung verteilt.


**Competencies**
- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Problem-solving

**Assessment**
- Fostered
- Assessed

### 252-0057-00L

**Theoretical Computer Science**

**Abstract**
Concepts to cope with: a) what can be accomplished in a fully automated fashion (algorithmically solvable) b) How to measure the inherent difficulty of tasks (problems) c) What is randomness and how can it be useful? d) What is nondeterminism and what role does it play in CST? e) How to represent infinite objects by finite automata and grammars?

**Objective**
Learning the basic concepts of computer science along their historical development. This lecture gives an introduction to theoretical computer science, presenting the basic concepts and methods of computer science in its historical context. We present computer science as an interdisciplinary science which, on the one hand, investigates the border between the possible and the impossible and the quantitative laws of information processing, and, on the other hand, designs, analyzes, verifies, and implements computer systems.

The main topics of the lecture are:
- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

**Content**
- Creative Thinking
- Critical Thinking

**Literature**

**Prerequisites**
Bachelor Studies (Programme Regulations 2016)

**ECTS**
7 credits

**Lecture notes**
The lecture is covered in detail by the textbook "Theoretical Computer Science".

**Assessment**
- Assessed
- Fostered

### 227-0045-00L

**Signals and Systems I**

**Abstract**

**Objective**
Introduction to mathematical signal processing and system theory.

**Content**

**Lecture notes**
The lecture is covered in detail by the textbook "Theoretical Computer Science".

**Assessment**
- Assessed
- Fostered

**Literature**

**Prerequisites**
Bachelor Studies (Programme Regulations 2016)

**ECTS**
4 credits

**Lecture notes**
The lecture notes, problem set with solutions.

**Assessment**
- Assessed
- Fostered

### Bachelor Studies (Programme Regulations 2016)

### Minor Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0351-00L</td>
<td>Astronomy</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. M. Glauser</td>
</tr>
</tbody>
</table>

**Abstract**
An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology

**Objective**
This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.

**Content**
Planeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie.
Core Courses (ONLY for Programme Regulations 2016)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0057-00L</td>
<td>Theoretical Computer Science</td>
<td>W</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>D. Komm, H.-J. Böckenhauer, J. Hromkovic</td>
</tr>
</tbody>
</table>

Abstract
- Concepts to cope with: a) what can be accomplished in a fully automated fashion (algorithmically solvable) b) How to measure the inherent difficulty of tasks (problems) c) What is randomness and how can it be useful? d) What is nondeterminism and what role does it play in CS? e) How to represent infinite objects by finite automata and grammars?

Objective
- Learning the basic concepts of computer science along their historical development

Content
- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

Lecture notes
The lecture is covered in detail by the textbook "Theoretical Computer Science".

Literature
- Basic literature:

Further reading:
- I. Wegener: Theoretische Informatik, Teubner.

More exercises and examples in:
- A. Asteroth, Ch. Baier: Theoretische Informatik

Core Courses: Pure Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3531-00L</td>
<td>Differential Geometry I</td>
<td>W</td>
<td>9 credits</td>
<td>4V+1U</td>
<td>U. Lang</td>
</tr>
</tbody>
</table>

Abstract
- Introduction to differential manifolds and differential geometry.
- Introduce the language, tools, and basic results of differentiable manifolds, tensors, Riemannian geometry, and related geometric structures. Relate geometric intuition to formulas involving curvature, derivatives and tensors.

Objective
- Learn to compute, describe, prove, and solve problems in the language of differential geometry.

Content
- Submanifolds of \( \mathbb{R}^n \), immersions, submersions, and embeddings. Sard's Theorem, abstract differentiable manifolds, charts, vector fields and flows, vector bundles, tensor fields, covariant derivatives, parallel transport, Riemannian metrics, geodesics, Riemann curvature tensor. Complete manifolds, Hopf-Rinow theorem. Many examples including curves, surfaces, hyperbolic space, S^3, the unit quaternions, the Gauss-Bonnet theorem, etc.

Literature
- John M. Lee: Introduction to Smooth Manifolds
- John M. Lee: Introduction to Riemannian Manifolds

This following books were inherited from before. The only one I know is DoCarmo.
- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie, Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds
### Core Courses: Pure Mathematics (Mathematics Master)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Type</th>
<th>Lecturer</th>
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<tbody>
<tr>
<td>401-3461-00L</td>
<td>Functional Analysis I</td>
<td>9</td>
<td>W</td>
<td>M. Burger</td>
</tr>
<tr>
<td>401-3391-00L</td>
<td>Algebraic Topology I</td>
<td>7</td>
<td>W</td>
<td>P. Biran</td>
</tr>
<tr>
<td>401-3312-00L</td>
<td>Commutative Algebra</td>
<td>9</td>
<td>W</td>
<td>C. Urech</td>
</tr>
</tbody>
</table>

#### Functional Analysis I

**Abstract**

At most one of the three course units (Bachelor Core Courses) 401-3461-00L Functional Analysis I, 401-3531-00L Differential Geometry I, 401-3601-00L Probability Theory can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

**Objective**

Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

**Literature**

Recommended references include the following:


**Prerequisites / notice**

Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH. Most importantly: fluency with point set topology and measure theory, in part. Lebesgue integration and L^p spaces.

### Algebraic Topology I

**Abstract**

This is an introductory course in algebraic topology, which is the study of algebraic invariants of topological spaces. Topics covered include:

- singular homology, cell complexes and cellular homology, the Eilenberg-Steenrod axioms.

**Literature**


Book can be downloaded for free at: http://www.math.cornell.edu/~hatcher/AT/ATpage.html

See also: http://www.math.cornell.edu/~hatcher/#anchor1772800

**Prerequisites / notice**

You should know the basics of point-set topology.

Useful to have (though not absolutely necessary) basic knowledge of the fundamental group and covering spaces (at the level covered in the course "topology").

Some knowledge of differential geometry and differential topology is useful but not strictly necessary.

Some (elementary) group theory and algebra will also be needed.

### Commutative Algebra

**Abstract**

This course provides an introduction to commutative algebra. It serves in particular as a foundation for modern algebraic geometry.
Objective

The topics presented in the course will include:

- Basics facts about rings, ideals, and modules
- Constructions of rings: quotients, polynomial rings, localization
- The prime spectrum of a ring
- Chain conditions, Noetherian/Artinian rings and modules
- The tensor product of modules over commutative rings
- Some homological algebra
- Integral extensions, going up, going down
- Finitely generated algebras over fields, including the Noether Normalization Theorem and the Nullstellensatz
- Discrete valuation rings and some applications
- Dimension theory

Literature

Primary Reference:
"Introduction to Commutative Algebra" by M. F. Atiyah and I. G. Macdonald (Addison-Wesley Publ., 1969)

Secondary References:

Prerequisites / notice

Prerequisites: Algebra I/II (or a similar introduction to the basic concepts of ring theory, including field theory).

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

401-3111-72L Number Theory I W 7 credits 4G E. Kowalski

Abstract
This course will give an introduction to various aspects of number theory, both algebraic and analytic.

Objective
The course will present some representative results in important directions of number theory. Students who attend the lecture will acquire a solid background in all aspects of modern number theory, both towards algebraic and analytic directions. They will also learn how to use software such as Pari/GP for experiments in number theory.

Content
The course will present some representative results in the following directions, each of which belongs to an important area of number theory:

1. congruences, including the law of Quadratic Reciprocity
2. diophantine approximation (Dirichlet's Theorem, continued fractions)
3. sums of two and four squares
4. elementary algebraic number theory
5. examples of Diophantine equations
6. the Prime Number Theorem
7. Dirichlet characters and primes in arithmetic progressions
8. Arithmetic functions and their statistical properties

The lecture will emphasize the connections between the topics and their links to current research. Moreover, computer experiments using Pari/GP and other software will be part of the lecture.

Lecture notes
The lecturer's notes will be scanned and available.

Literature
J-P. Serre, "A course in arithmetic"
Ireland and Rosen, "A classical introduction to modern number theory"
Hardy and Wright, "An introduction to the theory of numbers"
The course will address the mathematical analysis of numerical solution methods for linear and nonlinear elliptic and parabolic partial differential equations. Functional analytic and algebraic (De Rham complex) tools will be provided. Primal, mixed and nonstandard (discontinuous Galerkin, Virtual, Trefftz) discretizations will be analyzed. Particular attention will be placed on developing mathematical foundations (Regularity, Approximation theory) for a-priori convergence rate analysis. A-posteriori error analysis and mathematical proofs of adaptivity and optimality will be covered. Implementations for model problems in MATLAB and python will illustrate the theory.

A selection of the following topics will be covered:
- Elliptic boundary value problems
- Galerkin discretization of linear variational problems
- The primal finite element method
- Mixed finite element methods
- Discontinuous Galerkin Methods
- Boundary element methods
- Spectral methods
- Adaptive finite element schemes
- Singularly perturbed problems
- Sparse grids
- Galerkin discretization of elliptic eigenproblems
- Non-linear elliptic boundary value problems
- Discretization of parabolic initial boundary value problems

Literature


Additional Literature:

D. Braess: Finite Elements, THIRD Ed., Cambridge Univ. Press, (2007). (Also available in German.)


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**401-3601-00L Probability Theory**

At most one of the three course units (Bachelor Core Courses)

401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3642-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

**Abstract**

Basics of probability theory and the theory of stochastic processes in discrete time.

**Objective**

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

**Content**

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

**Lecture notes**

will be available in electronic form.

**Literature**


H. Bauer, Probability Theory, de Gruyter 1996

J. Jacod and P. Protter, Probability essentials, Springer 2004

A. Klenke, Wahrscheinlichkeitsrechnung, Springer 2006

D. Williams, Probability with martingales, Cambridge University Press 1991

**Prerequisites / notice**

- Measure Theory
- Basic notions in probability theory (probability space, conditional probability, Borel Cantelli, Dynkin Lemma, random variables, expectation, variance, law of large numbers).
In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.

**Fundamentals of Mathematical Statistics**

W 9 credits 4V+1U J. Ziegel

Abstract
In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

Objective
The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.

401-3621-00L Linear & Combinatorial Optimization

W 10 credits 4V+2U R. Zenklusen

Abstract
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content
Key topics include:
- Linear programming and polyheda;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature

Prerequisites / notice
Solid background in linear algebra.

401-3901-00L Statistical Modelling

W 7 credits 4G M. Kalisch

Abstract
In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression models, with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

Objective
Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

Content
In der Regression wird die Abhängigkeit einer beobachteten quantitativen Grösse von einer oder mehreren anderen (unter Berücksichtigung zufälliger Fehler) untersucht. Themen der Vorlesung sind: Einfache und multiple Regression, Theorie allgemeiner linearer Modelle, Hoch-dimensionale Modelle, Ausblick auf nichtlineare Modelle, Querverbindungen zur Varianzanalyse, Modellsuche, Residuenanalyse; Einblicke in Robuste Regression.

Prerequisites / notice
This is the course unit with former course title "Regression".

401-3622-00L Algorithms, Probability, and Computing

W 8 credits 4V+2U+1A B. Gärtner, R. Kyng, A. Steger, D. Steurer

Abstract
Advanced design and analysis methods for algorithms and data structures: Randomized Search Trees, Point Location, Minimum Cut, Linear Programming, Randomized Algebraic Algorithms (matchings), Probabilistically Checkable Proofs (introduction).

Objective
Studying and understanding of fundamental advanced concepts in algorithms, data structures and complexity theory.

Lecture notes
Will be handed out.

Literature
- Introduction to Algorithms by T. H. Cormen, C. E. Leiserson, R. L. Rivest;
- Randomized Algorithms by R. Motwani and P. Raghavan;

402-0205-00L Quantum Mechanics I

W 8 credits 3V+2U M. Krstic Marinkovic

Physics BSc students with programme regulations 2016 need to register for "402-0205-10L Quantenmechanik I"
Abstract

Objective
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

Content
The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.

Lecture notes
Auf Moodle

Literature
G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics

Competencies
Subject-specific Competencies

<table>
<thead>
<tr>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>fostered</td>
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Method-specific Competencies

<table>
<thead>
<tr>
<th>Analytical Competencies</th>
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<tbody>
<tr>
<td>Decision-making</td>
<td>fostered</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>fostered</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Project Management</td>
<td>fostered</td>
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</table>

Social Competencies

<table>
<thead>
<tr>
<th>Communication</th>
<th>fostered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>fostered</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>fostered</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>fostered</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
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<tr>
<td>Negotiation</td>
<td>fostered</td>
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</table>

Personal Competencies

<table>
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<tr>
<th>Adaptability and Flexibility</th>
<th>fostered</th>
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<tbody>
<tr>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>fostered</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>fostered</td>
</tr>
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</table>

Electives

➤ Selection: Algebra, Number Thy, Topology, Discrete Mathematics, Logic

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tbody>
<tr>
<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

Abstract
The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.

Objective
Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content
Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsdie's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

➤ Selection: Geometry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3057-00L</td>
<td>Finite Geometries</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

Abstract
Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.

Objective
Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content
Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsdie's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

Literature
- Max Jeger, Endliche Geometrien, ETH Skript 1988
- Albrecht Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983
- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press
- Dembowski: Finite Geometries.

➤ Selection: Analysis

➤ Selection: Numerical Analysis

➤ Selection: Probability Theory, Statistics
Abstract
This course is meant to serve as an introduction to the theory of Markov processes on finite or countable state spaces. We will discuss what a Markov process is along with associated concepts such as transition probabilities, recurrence, transience, ergodicity, reversibility etc. We will motivate various abstract notions introduced with concrete examples from physics and statistics.

Objective
I. Discrete-time Markov processes, i.e. Markov chains, e.g. the random walk on the integers
II. Transition probabilities and Doeblin's theorem
III. Stationary probabilities and ergodic properties
IV. Continuous-time Markov processes. e.g. the Poisson process
V. Reversibility

Literature
An Introduction to Markov Processes; Daniel W. Stroock

Prerequisites / notice
Recommended: Analysis III (measure theory)

Competencies
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making
- Social Competencies: Self-presentation and Social Influence
- Personal Competencies: Creative Thinking, Critical Thinking

401-3627-00L High-Dimensional Statistics
W 4 credits 2V not available
Does not take place this semester.

Abstract
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

Objective
Knowledge of methods and basic theory for high-dimensional statistical inference

Content
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

Literature

Prerequisites / notice
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

401-4623-00L Time Series Analysis
W 4 credits 2G F. Balabdaoui

Abstract
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARIMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARIMA, ARIMA, Introduction into GARCH models

Literature
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

Prerequisites / notice
Basic knowledge in probability and statistics

401-0625-01L Applied Analysis of Variance and Experimental Design
W 5 credits 2V+1U L. Meier

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
Basic knowledge in probability and statistics

401-0649-00L Applied Statistical Regression
W 5 credits 2V+1U M. Dettling

Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.
The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and permanent insurance).

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

A script will be available.

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Bayesian Statistics

Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayesian tests and model selection, empirical Bayes, Laplace approximations, Markov chain Monte Carlo methods.

Introduction to the frequentist approach to statistics: hypothesis testing, confidence intervals, regression models, analysis of variance. Work on practical applications are given.

Computers and Theories

Decision making, empirical Bayes, Laplace approximations, Markov chain Monte Carlo methods.

Method-specific Competencies

Analytical Competencies

Decision-making, assessed

Media and Digital Technologies

assessed

Problem-solving, assessed

Project Management

Fostered

Social Competencies

Communication

assessed

Cooperation and Teamwork

Fostered

Customer Orientation

Fostered

Leadership and Responsibility

Fostered

Self-presentation and Social Influence

Fostered

Sensitivity to Diversity

Fostered

Personal Competencies

Negotiation

Fostered

Adaptability and Flexibility

Assessed

Creative Thinking

Assessed

Critical Thinking

Assessed

Integrity and Work Ethics

Assessed

Self-awareness and Self-reflection

Fostered

Self-direction and Self-management

Fostered

Selection: Financial and Insurance Mathematics

In the Bachelor's programme in Mathematics 401-3913-01L Mathematical Foundations for Finance is eligible as an elective course, but only if 401-3888-00L Introduction to Mathematical Finance isn't recognised for credits (neither in the Bachelor's nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Life Insurance Mathematics

Life insurance models are presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of the life insurance industry are explained and illustrated.

Non-Life Insurance: Mathematics and Statistics

Non-life insurance models are presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of the life insurance industry are explained and illustrated.

Fostered
The following topics are treated:
- Collective Risk Modeling
- Claim Counts Models
- Individual Claim Size Modeling
- Censoring and Truncation
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tarification
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

Lecture notes
M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics
http://ssrn.com/abstract=2319328

Literature
M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications

Prerequisites / notice
The exams ONLY take place during the official ETH examination period (no semester end exams), and only in person exams (i.e. no remote exams).

This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Problem Management fostered

401-3927-00L Mathematical Modelling in Life Insurance W 4 credits 2V T. J. Peter

Abstract
In life insurance, it is essential to have adequate mortality rates, be it for reserving or pricing purposes. The course provides the classical tools necessary to create mortality tables from scratch as well as modern machine learning approaches to forecast mortality rates. It also covers the basics of survival analysis.

Objective
The course’s objective is to provide the students with the understanding and the tools to create mortality tables on their own. Additionally, students should learn the basics of survival analysis.

Content
Following main topics are covered:
- Determining raw mortality rates
- Smoothing techniques
- Trends in mortality rates
- Integration of safety margins
- Stochastic mortality model due to Lee and Carter
- Neural network extension of the Lee-Carter model
- Machine learning for mortality forecasts
- Survival analysis

Lecture notes
Lectures notes and slides will be provided

Prerequisites / notice
The exams ONLY take place during the official ETH examination period.

This course counts towards the diploma of “Aktuar SAV”.

Basic knowledge in probability theory is assumed. Some knowledge in financial mathematics is useful.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed

401-3931-00L Responsible Machine Learning with Insurance Applications W 4 credits 2G M. Mayer, C. Lorentzen-Geiser

Abstract
This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

Objective
The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

Content
- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

Prerequisites / notice
This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Prerequisites: Good knowledge in statistics/probability theory, statistical modelling and Python (or R) programming are assumed.

Competencies

Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered

402-0830-00L General Relativity W 10 credits 4V+2U R. Renner

Abstract
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.
Sensitivity to Diversity

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content

Does not take place this semester.

Objective

Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).

Content

Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

Literature

Suggested textbooks:
C. Misner, K. Thorne and J. Wheeler: Gravitation
S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
R. Wald - General Relativity
S. Weinberg - Gravitation and Cosmology

402-0822-13L Introduction to Integrability

Abstract

This course gives an introduction to the theory of integrable systems, related symmetry algebras and efficient calculation methods.

Objective

Integrable systems are a special class of physical models that can be solved exactly due to an exceptionally large number of symmetries. Examples of integrable models appear in many different areas of physics including classical mechanics, condensed matter, 2d quantum field theories and lately in string- and gauge theories. They offer a unique opportunity to gain a deeper understanding of generic phenomena in a simplified, exactly solvable setting. In this course we introduce the notion and formulation of integrability in classical and quantum mechanics. We discuss various efficient methods for constructing solutions and eigenstates in these models. Finally, we elaborate on the enhanced symmetries that underly integrable models.

Content

• Classical Integrability
• Algebraic Methods for Integrability
• Classical Spin Chains
• Spectral Curves and Inverse Scattering
• Quantum Spin Chains
• Bethe Ansatz
• Classical and Quantum Algebra

Literature

• Lecture of HS23: https://moodle-app2.let.ethz.ch/course/view.php?id=21116

Competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Social Competencies

Sensitivity to Diversity

Personal Competencies

Adaptability and Flexibility

Critical Thinking

Prerequisites / notice

Students are expected to have a mathematical background and should be able to write rigorous proofs.

Lecture notes

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

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401-3054-14L Probabilistic Methods in Combinatorics

Abstract

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content

The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

S. Weinberg - Gravitation and Cosmology

S. Weinberg - Gravitation and Cosmology

5 credits

2V+1U

2V+1U

B. Sudakov

5 credits

2V+1U

Autumn Semester 2024

401-3054-13L Probabilistic Methods in Combinatorics
Projects in Topological Data Analysis

Lecturers

B. Häupler, M. Probst

Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in Rd, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting polygon triangulations.

Abstract

The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains.

In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

Content

Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in Rd, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting polygon triangulations.

Lecturers

J. Lengler, P. Schnider

Prerequisites / notice

This course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

Literature


Selection: Further Realms and Some UZH Courses

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
401-3502-72L | Reading Course | W | 2 credits | 4A | Supervisors

Abstract

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
401-3503-72L | Reading Course | W | 3 credits | 6A | Supervisors

Abstract

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
401-3504-72L | Reading Course | W | 4 credits | 9A | Supervisors

Abstract

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
263-4511-00L | Projects in Topological Data Analysis | W | 4 credits | 3A | P. Schnider

Summary

- **Selection: Theoretical Computer Science**
  - **Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
  - 252-1425-00L | Geometry: Combinatorics and Algorithms | W | 8 credits | 3V+2U+2A | B. Gärtner, M. Hoffmann, P. Schneider

- **Selection: Further Realms and Some UZH Courses**
  - **Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
  - 401-3502-72L | Reading Course | W | 2 credits | 4A | Supervisors
  - 401-3503-72L | Reading Course | W | 3 credits | 6A | Supervisors
  - 401-3504-72L | Reading Course | W | 4 credits | 9A | Supervisors
  - 263-4511-00L | Projects in Topological Data Analysis | W | 4 credits | 3G | P. Schnider

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Abstract
This seminar complements the course „Introduction to Topological Data Analysis“. Students of the seminar will collaborate with students from international universities on concrete projects in topological data analysis, both theoretical and applied.

Objective
Each student is expected to collaborate in an international working group with students from the partner universities. Each group works on one of the projects suggested by the lecturers, and is assigned a mentor. At the end of the semester, each working group presents their findings in a written report and an oral presentation.

Content
This seminar complements the course Introduction to Topological Data Analysis. Students get to apply what they learned in the introductory course to concrete projects in the area of topological data analysis. These projects can be of theoretical nature, e.g., the design and analysis of a new algorithm, or applied, such as using methods from topological data analysis on concrete data sets.

Prerequisites / notice
Successful participation in the course “Introduction to Topological Data Analysis“ or equivalent background in topological data analysis is required.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Conceptual and Theoretical</th>
<th>fostered</th>
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</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>fostered</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>fostered</td>
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<td></td>
<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
</tbody>
</table>

401-3005-00L Mathematical Writing

W 7 credits 3V+1U+2A F. Yang

Abstract
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective
By the end of the semester students should be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning“, “Regression“, “Statistical Modelling“. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Core Courses and Electives (Mathematics Master)

Core Courses (Mathematics Master)

Electives (Mathematics Master)

Electives (only conditionally recognised)
In the Bachelor's programme in Mathematics 401-3913-01L Mathematical Foundations for Finance is eligible as an elective course, but only if 401-3888-00L Introduction to Mathematical Finance isn’t recognised for credits (neither in the Bachelor's nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.
### 401-3913-01L Mathematical Foundations for Finance

**W 4 credits 3V+2U D. Possamaï**

**Abstract**
First introduction to main modelling ideas and mathematical tools from mathematical finance

**Objective**
This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

**Content**
Topics to be covered include
- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

**Lecture notes**
See information on course homepage

**Prerequisites / notice**
Prerequisites: Results and facts from probability theory as in the book “Probability Essentials” by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course “Wahrscheinlichkeitstheorie”.)

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
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<tr>
<td>Techniques and Technologies</td>
<td>fostered</td>
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<th>Method-specific Competencies</th>
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<tbody>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>fostered</td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
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<tr>
<td>Creative Thinking</td>
<td>fostered</td>
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<tr>
<td>Critical Thinking</td>
<td>fostered</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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</table>

### Seminars

**NOTICE:** The number of seminar places is limited, and the special selection procedure should help to allocate the places not primarily according to the registration time. Everybody is waitlisted first when he/she tries to register for such a seminar in myStudies. Moreover: Only one mathematics seminar can be chosen per semester. Notice also the course unit 401-0002-99L Generic Seminar - Second Priority / Third Priority.

#### Number of participants limited to 24.

- Students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have heard at least one core or elective course in statistics. Also offered in the Master Programmes Statistics resp. Data Science.

#### Number of participants limited to 12.

- Mainly for students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have heard at least one core or elective course in statistics. Also offered in the Master Programmes Statistics resp. Data Science.

### 401-0002-99L Generic Seminar - Second Priority / Third Priority

**E- 0 credits**

**Here you can indicate seminars of second and third priority if you cannot be admitted to your preferred seminar. Use the "Group assignment" in myStudies.**

### 401-3620-74L Student Seminar in Statistics: ...

**W 4 credits 2S Y. Chen**

**Abstract**
Mainly for students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have heard at least one core or elective course in statistics. Also offered in the Master Programmes Statistics resp. Data Science.

**Objective**
The seminar will consist of student presentations and will cover a variety of topics in modern-day combinatorics. The seminar is aimed at third year bachelor students or master students with a background in combinatorics (e.g. the Graph Theory course).

**Content**
The seminar's aim is to acquaint students with interesting results, proofs and techniques in combinatorics and graph theory, and to give them the opportunity to work with advanced research papers and practice their presentation skills.

### 401-3050-72L Student Seminar in Combinatorics

**W 4 credits 2S B. Sudakov**

**Abstract**
The seminar will consist of student presentations and will cover a variety of topics in modern-day combinatorics. The seminar is aimed at third year bachelor students or master students with a background in combinatorics (e.g. the Graph Theory course).

**Content**

### 401-3140-74L Student Seminar in Numerical Algebraic Geometry

**W 4 credits 2S C. Meroni**

**Abstract**
Numerical algebraic geometry is a research area that aims to use numerical methods to solve systems of polynomial equations. Sometimes, these numerical algorithms can be turned into theoretical, exact proofs, as we will see. The lectures will cover two major research directions in numerical algebraic geometry: the theory of normal forms and homotopy continuation methods.

**Content**
Student Seminar on Harmonic Analysis
Number of participants limited to 12.

401-3940-74L Student Seminar in Mathematics and Data Science: Statistical-to-Computational Gaps
Number of participants limited to 12.

W 4 credits 2S  A. Bandeira, further speakers

Number of participants limited to 12.

401-3650-74L Port-Hamiltonian Systems: Mathematical Aspects
Abstract
The seminar covers theory and applications of port-Hamiltonian system models based on current literature. The various topics have to be presented by groups of students.

Objective
Participants of the seminar should acquire familiarity with the concept of port-Hamiltonian systems and the relevant mathematical theory for their analysis. They should be enabled to devise and understand port-Hamiltonian models of physical systems.

Content
Port-Hamiltonian provide a mathematical framework for the modeling of complex (multi-physics) systems, of their dynamical behavior, for understanding their stability and effective control. They are based on geometric structure and represent a generalization of Hamiltonian systems towards open systems. The building blocks of port-Hamiltonian systems are thought to interact by exchanging energy. So the main focus of port-Hamiltonian modeling is on accurately representing the flow, storage, and dissipation of energy.

Port-Hamiltonian models are ubiquitous nowadays, used in areas like mechanics, fluid dynamics, thermodynamics, and (electric) circuits. They play a big role in modern control theory and are a highly active field of theoretical and applied research.

This seminar will study a number of monograph chapters and research papers dealing with both theoretical and application aspects of post-Hamiltonian system models.

Topics:
Student groups will be decided and topics will be assigned during the preparatory meeting.


Good skills in linear algebra and ordinary differential equations are required

Prerequisite / notice
Preparatory meeting on
Every presentation has to be done jointly by a group of 2-3 students with presenters selected at random. Every participant will have to present on 2-3 occasions.


Competencies

Subject-specific Competencies
- Concepts and Theories
  - assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
- Media and Digital Technologies
  - Problem-solving
  - assessed
- Customer Orientation
  - fostered

Social Competencies
- Communication
  - assessed
- Cooperation and Teamwork
  - assessed
- Customer Orientation
  - fostered

Personal Competencies
- Critical Thinking
  - assessed
- Self-awareness and Self-reflection
  - assessed

Stability of Phase Retrieval Problems

W 4 credits 2S

Bachelor’s Thesis

Seminars (Mathematics Master)

Number Title Type ECTS Hours Lecturers
401-2000-00L Scientific Works in Mathematics O 0 credits D. Possamaï

Target audience:
Third year Bachelor students;
Master students who cannot document to have received an adequate training in working scientifically.

Abstract
Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)

Objective
Learn the basic standards of scientific works in mathematics.
- Types of mathematical works
- Publication standards in pure and applied mathematics
- Data handling
- Ethical issues
- Citation guidelines

Prerequisite / notice

401-2000-01L Lunch Sessions – Thesis Basics for Mathematics Students Z 0 credits Speakers

Details and registration for the optional MathBib training course: https://www.math.ethz.ch/mathbib-schulungen

Abstract
Optional MathBib training course

401-3990-10L Bachelor’s Thesis O 8 credits 17D Supervisors

Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics is required.
For more information, see https://math.ethz.ch/intranet/students/theses.html

Abstract
The purpose of the BSc thesis is to deepen knowledge in a certain subject chosen by the student. In their BSc thesis, students should demonstrate their ability to carry out independent work in mathematics and to organize results in a written report.

Science in Perspective

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Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MATH

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>A. Bandeira, S. Mishra, R. Pandharipande, University lecturers</td>
</tr>
<tr>
<td>401-5990-00L</td>
<td>Zurich Graduate Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>0.5K</td>
<td>University lecturers, further speakers</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>The Graduate Colloquium is an informal seminar aimed at graduate students and postdocs whose purpose is to provide a forum for communicating one's interests and thoughts in mathematics.</td>
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</tr>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>N. Hungerbühler, M. Akveld, D. Grawehr Morath, D. Komm, P. Spindler</td>
</tr>
<tr>
<td></td>
<td>Subject didactics for mathematics and computer science teachers.</td>
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<tr>
<td></td>
<td>Abstract</td>
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</tr>
<tr>
<td></td>
<td>Didactics colloquium</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<tr>
<td></td>
<td>Research colloquium</td>
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<tr>
<td></td>
<td>The goal of this event is to bring you closer to current day research in all fields of physics. In each semester we have a set of distinguished speakers covering the full range of topics in physics. As a participating student should learn how to follow a research talk. In particular, you should be able to extract key points from a colloquium where you don't necessarily understand every detail that is presented.</td>
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</tr>
<tr>
<td>402-0800-00L</td>
<td>The Zurich Theoretical Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>J. Renes, University lecturers</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Research colloquium</td>
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<tr>
<td></td>
<td>The Zurich Theoretical Physics Colloquium is jointly organized by the University of Zurich and ETH Zurich. Its mission is to bring both students and faculty with diverse interests in theoretical physics together. Leading experts explain the basic questions in their field of research and communicate the fascination for their work.</td>
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<tr>
<td>251-0100-00L</td>
<td>Computer Science Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>2K</td>
<td>Lecturers</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Invited talks, covering the entire scope of computer science. External Listeners are welcome at no charge. A detailed schedule is published at the beginning of each semester.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Top international computer scientists take the floor at the distinguished computer science colloquium. Our guest speakers present impacting topics across various areas of the discipline. The colloquium series is held every semester and also includes inaugural and farewell lectures of the department's professors. The colloquium is a noteworthy event for all graduate students. Outside attendance is equally welcome.</td>
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<tr>
<td></td>
<td>Content</td>
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</tr>
<tr>
<td></td>
<td>Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.</td>
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</tbody>
</table>

Mathematics Bachelor - Key for Type

| O   | Compulsory                      | E- | Recommended, not eligible for credits |
| W+  | Eligible for credits and recommended | Z | Courses outside the curriculum         |
| W   | Eligible for credits            | Dr | Suitable for doctorate                |

Key for Hours

| V   | lecture                        | P  | practical/laboratory course          |
| G   | lecture with exercise          | A  | independent project                  |
| U   | exercise                       | D  | diploma thesis                       |
| S   | seminar                        | R  | revision course / private study      |
| K   | colloquium                     |    |                                         |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Mathematics TC

Detailed information on the programme at: www.ethz.ch/didaktische-ausbildung

Educational Science

General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Markwalder</td>
</tr>
<tr>
<td></td>
<td>Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport); This course unit can only be enrolled after successful participation in the course 871-0240-00L &quot;Human Learning (EW 1)&quot;.</td>
<td></td>
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</tr>
</tbody>
</table>

Objective

Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.).

Prerequisites / notice

https://www.minterlink.ch/student

Subject Didactics and Professional Training

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Enrolment in either Mathematics Didactics I or Mathematics Didactics II (spring semester) is compulsory.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3971-11L</td>
<td>Mathematics Didactics I</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>A. Barth</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Mathematics Teaching Diploma or Mathematics TC at ETH or in Mathematics Teaching Diploma at UZH.</td>
<td></td>
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</tr>
</tbody>
</table>

Objective

On the basis of their understanding of mathematics, of the knowledge acquired from research into teaching/learning and subject teaching, and also of best practice, students who have completed this course will be in a position to draft motivating learning arrangements, with cognitive appeal, which trigger and maintain learning processes. The aim here is to implement a corresponding teaching plan, so that the mathematics tuition that is given has a general-education value, on the one hand, and ensures that pupils acquire the fundamental knowledge necessary for studying at university, on the other hand.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-9987-00L</td>
<td>Teaching Internship Including Examination Lessons Mathematics</td>
<td>O</td>
<td>4</td>
<td>9P</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td></td>
<td>Teaching Internship Mathematics for TC. Repetition of the Teaching Internship is excluded even if Examination Lessons are to be repeated.</td>
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</tr>
</tbody>
</table>

Objective

Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.

- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.
Finite Geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of experiments, and the construction of orthogonal Latin squares.

Objective
- to be able to analyse models with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content
Thematic Schwerpunkte
Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Specialized Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3057-00L</td>
<td>Finite Geometries II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>401-0293-00L</td>
<td>Mathematics III</td>
<td>W</td>
<td>5</td>
<td>3+2U</td>
<td>A. Caspar, N. Hungerbühler</td>
</tr>
</tbody>
</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1877 of 2667
Einführung Modellbildung

- SIR-Modelle: Ausbreitung von Krankheiten bei Epidemien
- Pocken-Modell: Was ist der Effekt von Impfungen?

Lineare Modelle

- Vektorräume
- Lösungsraum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen

- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle

- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen: Vorgänge, die von Raum und Zeit abhängen

- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Laplace-Transformation

- Definition und Notation
- Rechenregeln
- Anwendungsbeispiele

Lecture notes

Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)

Literature

- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)
- Blatter, C.: Lineare Algebra für Ingenieure, Chemiker und Naturwissenschaftler. (Siehe später Polybox)

Prerequisites / notice

Vorlesungen Mathematik I/II

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking

401-9985-00L

Mentored Work Specialised Courses in the Respective Subject with an Educational Focus Mathematics A

Subject didactics for mathematics and computer science teachers.

ECTS 2 credits 4A

Abstract

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective

The aim is for the students to
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content

Thematische Schwerpunkte:


Lernformen:


Lecture notes

Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Colloquia

Number Title Type ECTS Hours Lecturers
401-5960-00L Colloquium on Mathematics, Computer Science, and Education Subject didactics for mathematics and computer science teachers. E- 0 credits N. Hungerbühler, M. Akved, D. Grawehr Morath, D. Komm, P. Spindler

Abstract

Didactics colloquium
<table>
<thead>
<tr>
<th>Mathematics TC - Key for Type</th>
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</thead>
<tbody>
<tr>
<td>O Compulsory</td>
<td>E- Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+ Eligible for credits and recommended</td>
<td>Z Courses outside the curriculum</td>
</tr>
<tr>
<td>W Eligible for credits</td>
<td>Dr Suitable for doctorate</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>V lecture</td>
<td>P practical/laboratory course</td>
</tr>
<tr>
<td>G lecture with exercise</td>
<td>A independent project</td>
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<tr>
<td>U exercise</td>
<td>D diploma thesis</td>
</tr>
<tr>
<td>S seminar</td>
<td>R revision course / private study</td>
</tr>
<tr>
<td>K colloquium</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Mentored Work Subject Didactics Mathematics A

Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.

Abstract

Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching various topics in mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

Objective

On the basis of their understanding of mathematics, of the knowledge acquired from research into teaching/learning and subject teaching, and also of best practice, students who have completed this course will be in a position to draft motivating learning arrangements, with cognitive appeal, which trigger and maintain learning processes. The aim here is to implement a corresponding teaching plan, so that the mathematics tuition that is given has a general-education value, on the one hand, and ensures that pupils acquire the fundamental knowledge necessary for studying at university, on the other hand.

Mentoring Work Subject Didactics Mathematics A

Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.

Content

Thematische Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


Literatur

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Mentoring Work Subject Didactics Mathematics B

Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.

Content

Thematische Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


Literatur

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Professional Training in Mathematics

Introductory Internship Mathematics

Enrollment only possible with matriculation in Mathematics Teaching Diploma or Mathematics TC at ETH. It is advisable to enrol in this course not prior to the first Mathematics Didactics course and not after the second Mathematics Didactics course.
During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.

Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for teaching and the implementation of teaching. This early confrontation with the complexity of everything that teaching involves helps students decide whether they wish to and, indeed, ought to, continue with the training. It forms a basis for the subsequent pedagogical and subject-didactics training.


This course is to be chosen jointly with 401-3972-00L.

This course finds verbindlich am Schluss der Ausbildung, vor dem Ablegen der Prüfungslektion statt. Allfällige fachwissenschaftliche Aufgaben sind ebenfalls vor Antritt des Praktikums zu erfüllen.

This is a supplement to the Teaching Internship required to obtain a Master of Advanced Studies in Secondary and Higher Education in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.

The Aufbaupraktikum richtet sich an Studierende, die den Didaktik-Zertifikat in ihrem Fach erworben haben und nun eine effektiv flexibel nutzbare Aufführung (Fach-)Wissen zu erwerben.

In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

On the basis of a specified topic, the candidate shows that they are in a position to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Enrolment only possible with matriculation in Mathematics Teaching Diploma or Mathematics TC at ETH. Simultaneous enrolment in Mathematics Didactics - course unit 401-3971-11L is compulsory.

Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

On the basis of their understanding of mathematics, of the knowledge acquired from research into teaching/learning and subject teaching, and also of best practice, students who have completed this course will be in a position to draft motivating learning arrangements, with cognitive appeal, which trigger and maintain learning processes. The aim here is to implement a corresponding teaching plan, so that the mathematics tuition that is given has a general-education value, on the one hand, and ensures that pupils acquire the fundamental knowledge necessary for studying at university, on the other hand.

This course is to be chosen jointly with 401-3988-00L.

This is a supplement to the Teaching Internship required to obtain a Master of Advanced Studies in Secondary and Higher Education in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.

This is a supplement to the Teaching Internship required to obtain a Master of Advanced Studies in Secondary and Higher Education in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.

This is a supplement to the Teaching Internship required to obtain a Master of Advanced Studies in Secondary and Higher Education in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.

This course is to be chosen jointly with 401-3971-11L.

This is a supplement to the Teaching Internship required to obtain a Master of Advanced Studies in Secondary and Higher Education in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.
Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of Desargues and Pappus-Pascal. Die gehaltene Lektion wird kriteriumsgebunden beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/ der Kandidatin über die gehaltene Lektion im Rahmen eines kurzen Kolloquiums.

Lecture notes
Dokument: Schriftliche Vorbereitung für Prüfungslektionen.

Prerequisites / notice
Nach Abschluss der übrigen Ausbildung.

<table>
<thead>
<tr>
<th>401-9991-02L</th>
<th>Examination Lesson II Mathematics</th>
<th>O</th>
<th>1 credit</th>
<th>2P</th>
<th>N. Hungerbühler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>On the basis of a specified topic, the candidate shows that they are in a position - to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle - to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.</td>
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<tr>
<td>Lecture notes</td>
<td>Dokument: Schriftliche Vorbereitung für Prüfungslektionen.</td>
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<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Nach Abschluss der übrigen Ausbildung.</td>
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</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Content</td>
<td>Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsides' lemma, cycle index, Polya's theorems, applications to graph theory and isomers.</td>
<td></td>
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</tr>
</tbody>
</table>

| 401-3057-00L| Finite Geometries II         | W    | 4 credits | 2G | N. Hungerbühler |
| Abstract    | Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares. |
| Objective   | Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design. |
| Content     | Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design |
| Literature  | - Max Jeger, Endliche Geometrien, ETH Skript 1988 |
|            | - Albrecht Beutelspacher: Einführung in die endliche Geometrie I.II. Bibliographisches Institut 1983 |
|            | - Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press |
|            | - Dembowski: Finite Geometries. |

| 401-0293-00L| Mathematics III              | W    | 5 credits | 3V+2U | A. Caspar, N. Hungerbühler |

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Content

- Einführung Modellbildung
- SIR-Modelle: Ausbreitung von Krankheiten bei Epidemien
- Pocken-Modell: Was ist der Effekt von Impfungen?

Lineare Modelle
- Vektorräume
- Lösungsräum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen
- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle
- Stationäre Lösungen, Qualitative Aussagen
- Mehdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen: Vorgänge, die von Raum und Zeit abhängen
- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Laplace-Transformation
- Definition und Notation
- Rechenregeln
- Anwendungsbeispiele

Lecture notes
- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)
- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)
- Blatter, C.: Lineare Algebra für Ingenieure, Chemiker und Naturwissenschaftler. ((Siehe später Polybox)

Literature
- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler (Siehe Lernmaterial/Literatur)
- Blatter, C.: Lineare Algebra für Ingenieure, Chemiker und Naturwissenschaftler. ((Siehe später Polybox)

Prerequisites / notice
- Vorlesungen Mathematik I/II

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking

401-9985-00L Mentored Work Specialised Courses in the Respective Subject with an Educational Focus Mathematics A
Subject with an Educational Focus in Mathematics for TC and Teaching Diploma.

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
The aim is for the students - to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- To independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content
Thematische Schwerpunkte:

Lernformen:

Lecture notes
Eine Anleitung zur mentorisierten Arbeit in FV wird zur Verfügung gestellt.

Literature
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

401-9986-00L Mentored Work Specialised Courses in the Respective Subject with an Educational Focus Mathematics B
Subject with an Educational Focus in Mathematics for Teaching Diploma and for students upgrading TC to Teaching Diploma.

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.
### Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.</td>
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<tr>
<td>Objective</td>
<td>Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.</td>
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<tr>
<td>Content</td>
<td>Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsdie's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.</td>
<td></td>
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<tr>
<td>Literature</td>
<td>- Max Jeger, Endliche Geometrien, ETH Skript 1988</td>
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<tr>
<td></td>
<td>- Alfred Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983</td>
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<td></td>
<td>- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press</td>
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<td></td>
<td>- Dambowski: Finite Geometries.</td>
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<tr>
<td>401-3057-00L</td>
<td>Finite Geometries II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.</td>
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<tr>
<td>Objective</td>
<td>Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.</td>
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<tr>
<td>Content</td>
<td>Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design</td>
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<tr>
<td>Literature</td>
<td>- K. Dembowski: Finite Geometries</td>
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<tr>
<td>252-0855-00L</td>
<td>Computer Science in Secondary School Mathematics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Komm, J. Hromkovic, G. Serafini</td>
</tr>
<tr>
<td>Abstract</td>
<td>The unit &quot;Computer Science in Secondary School Mathematics&quot; addresses key contributions of computer science to general education, the tight relations between the algorithmic and the mathematical way of thinking, and the thoughtful choice of computer science topics for high school mathematics classes.</td>
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<tr>
<td>Objective</td>
<td>The general goal of the course consists in presenting ways to teach fundamentals of computer science, which are closely related to contents and methods of mathematics. After attending the course unit, a mathematics teacher is able to teach selected fundamentals of computer science in mathematics classes.</td>
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<tr>
<td>Content</td>
<td>The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.</td>
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<td>The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support. They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.</td>
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<td>The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.</td>
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<tr>
<td>Literature</td>
<td>- Santrach: Computer Science for Secondary Education</td>
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<td></td>
<td>- To try out different options for specialist further training in their profession.</td>
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<td>- The course covers the didactics of logic, of cryptography, of finite state automata, of computability and of the introduction to programming. The students develop the understanding of fundamental scientific concepts such as algorithm, program, complexity, determinism, computation, automata, verification, testing, security of a cryptosystem and secure communication. They reflect on ways to embed them into a scientifically sound and didactically sustainable mathematics course.</td>
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<td></td>
<td>In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.</td>
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<tr>
<td>Lecture notes</td>
<td>Literatur wird angegeben. Zusätzliche Unterlagen und Folien werden zur Verfügung gestellt.</td>
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</tr>
</tbody>
</table>
Literature

J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen" Lehrwerksreihe "Einfach Informatik"
https://einfachinformatik.inf.ethz.ch/


see Compulsory Elective Courses Teaching Diploma

Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>N. Hungerbühler, M. Akveld, D. Grawehr Morath, D. Komm, P. Spindler</td>
</tr>
</tbody>
</table>

Abstract
Didactics colloquium

Mathematics Teaching Diploma - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>A</td>
<td>independent project</td>
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<td>U</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>R</td>
<td>revision course / private study</td>
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<td>K</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
For the Master's degree in Applied Mathematics the following additional condition (not manifest in myStudies) must be obeyed: At least 14 of the required 26 credits from core courses and electives must be acquired in areas of applied mathematics and further application-oriented fields.

### Core Courses: Pure Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3001-61L</td>
<td>Algebraic Topology I</td>
<td>W</td>
<td>7 credits</td>
<td>4G</td>
<td>P. Biran</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>This is an introductory course in algebraic topology, which is the study of algebraic invariants of topological spaces. Topics covered include: singular homology, cell complexes and cellular homology, the Eilenberg-Steenrod axioms.</td>
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<tr>
<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>Book can be downloaded for free at: <a href="http://www.math.cornell.edu/~hatcher/AT/ATpage.html">http://www.math.cornell.edu/~hatcher/AT/ATpage.html</a></td>
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<td></td>
<td>See also:</td>
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<td><a href="http://www.math.cornell.edu/~hatcher/#anchor1772800">http://www.math.cornell.edu/~hatcher/#anchor1772800</a></td>
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<td></td>
<td>Prerequisites / notice</td>
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<td></td>
<td>Useful to have (though not absolutely necessary) basic knowledge of the fundamental group and covering spaces (at the level covered in the course &quot;topology&quot;).</td>
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<td>Some knowledge of differential geometry and differential topology is useful but not strictly necessary.</td>
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<td>Some (elementary) group theory and algebra will also be needed.</td>
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<tr>
<td>401-3132-00L</td>
<td>Commutative Algebra</td>
<td>W</td>
<td>9 credits</td>
<td>4V+1U</td>
<td>C. Urech</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>This course provides an introduction to commutative algebra. It serves in particular as a foundation for modern algebraic geometry.</td>
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<td></td>
<td>Objective</td>
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<td>The topics presented in the course will include:</td>
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<td></td>
<td>* Basics facts about rings, ideals, and modules</td>
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<td>* Constructions of rings: quotients, polynomial rings, localization</td>
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<td></td>
<td>* The prime spectrum of a ring</td>
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<td>* Chain conditions, Noetherian/Artinian rings and modules</td>
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<td></td>
<td>* The tensor product of modules over commutative rings</td>
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<td></td>
<td>* Some homological algebra</td>
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<td></td>
<td>* Integral extensions, going up, going down</td>
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<td></td>
<td>* Finitely generated algebras over fields, including the Noether Normalization Theorem and the Nullstellensatz</td>
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<td></td>
<td>* Discrete valuation rings and some applications</td>
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<td></td>
<td>* Dimension theory</td>
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<td></td>
<td>Literature</td>
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<td>Primary Reference:</td>
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<tr>
<td></td>
<td>&quot;Introduction to Commutative Algebra&quot; by M. F. Atiyah and I. G. Macdonald (Addison-Wesley Publ., 1969)</td>
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<td>Secondary References:</td>
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<td>Prerequisites / notice</td>
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<td>Prerequisites: Algebra III (or a similar introduction to the basic concepts of ring theory, including field theory).</td>
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<tr>
<td>401-3111-72L</td>
<td>Number Theory I</td>
<td>W</td>
<td>7 credits</td>
<td>4G</td>
<td>E. Kowalski</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>This course will give an introduction to various aspects of number theory, both algebraic and analytic.</td>
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<td>Objective</td>
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<td>The course will present some representative results in important directions of number theory. Students who attend the lecture will acquire a solid background in all aspects of modern number theory, both towards algebraic and analytic directions. They will also learn how to use software such as Pari/GP for experiments in number theory.</td>
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<td></td>
<td>Content</td>
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<td>The course will present some representative results in the following directions, each of which belongs to an important area of number theory:</td>
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<td>(1) congruences, including the law of Quadratic Reciprocity</td>
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<td>(2) diophantine approximation (Dirichlet's Theorem, continued fractions)</td>
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<td>(3) sums of two and four squares</td>
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<td>(4) elementary algebraic number theory</td>
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<td>(5) examples of Diophantine equations</td>
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<td>(6) the Prime Number Theorem</td>
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<td>(7) Dirichlet characters and primes in arithmetic progressions</td>
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<td>(8) Arithmetic functions and their statistical properties</td>
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<td>The lecture will emphasize the connections between the topics and their links to current research. Moreover, computer experiments using Pari/GP and other software will be part of the lecture.</td>
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<td></td>
<td>Lecture notes</td>
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<td>The lecturer's notes will be scanned and available.</td>
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<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>J-P. Serre, &quot;A course in arithmetic&quot;</td>
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<td></td>
<td>Ireland and Rosen, &quot;A classical introduction to modern number theory&quot;</td>
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<td>Hardy and Wright, &quot;An introduction to the theory of numbers&quot;</td>
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</tbody>
</table>
Prerequisites / notice
Algebra I and II (Rings, Fields, Galois theory)
Analysis I and II
Integration theory
Complex analysis

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies fostered
Problem-solving fostered

Method-specific Competencies

Personal Competencies
Creative Thinking fostered

401-3226-00L Symmetric Spaces W 7 credits 4G A. Iooss

Abstract
* Generalities on symmetric spaces: locally and globally symmetric spaces, groups of isometries, examples
* Symmetric spaces of non-compact type: flats and rank, roots and root spaces
* Iwasawa decomposition, Weyl group, Cartan decomposition
* Geometry at infinity

Objective
Learn the basics of symmetric spaces

Core Courses: Applied Mathematics and Further Appl.-Oriented Fields

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3651-00L</td>
<td>Numerical Methods for Elliptic and Parabolic Partial Differential Equations</td>
<td>W</td>
<td>9 credits</td>
<td>4V+1U</td>
<td>J. Nick</td>
</tr>
</tbody>
</table>

Abstract
This course gives a comprehensive introduction into the numerical treatment of linear and nonlinear elliptic boundary value problems, related eigenvalue problems and linear, parabolic evolution problems. Emphasis is on theory and the foundations of numerical methods. Practical exercises include MATLAB implementations of finite element methods.

Objective
Participants of the course should become familiar with:
* concepts underlying the discretization of elliptic and parabolic boundary value problems
* analytical techniques for investigating the convergence of numerical methods for the approximate solution of boundary value problems
* methods for the efficient solution of discrete boundary value problems
* implementation aspects of the finite element method

Content
The course will address the mathematical analysis of numerical solution methods for linear and nonlinear elliptic and parabolic partial differential equations. Functional analytic and algebraic (De Rham complex) tools will be provided. Primal, mixed and nonstandard (discontinuous Galerkin, Virtual, Trefftz) discretizations will be analyzed.

Particular attention will be placed on developing mathematical foundations (Regularity, Approximation theory) for a-priori convergence rate analysis. A-posteriori error analysis and mathematical proofs of adaptivity and optimality will be covered. Implementations for model problems in MATLAB and python will illustrate the theory.

A selection of the following topics will be covered:
* Elliptic boundary value problems
* Galerkin discretization of linear variational problems
* The primal finite element method
* Mixed finite element methods
* Discontinuous Galerkin Methods
* Boundary element methods
* Spectral methods
* Adaptive finite element schemes
* Singularly perturbed problems
* Sparse grids
* Galerkin discretization of elliptic eigenproblems
* Non-linear elliptic boundary value problems
* Discretization of parabolic initial boundary value problems

Literature

Additional Literature:
D. Braess: Finite Elements, THIRD Ed., Cambridge Univ. Press, (2007). (Also available in German.)

401-3621-00L Fundamentals of Mathematical Statistics W 9 credits 4V+1U J. Ziegel

Abstract
In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1887 of 2667
**Objective**
The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today’s highly complex models.

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Problem-solving: assessed

- **Method-specific Competencies**
  - Creative Thinking: assessed

**Statistical Modelling**

- **Abstract**
  In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

- **Objective**
  Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

- **Content**
  In der Regression wird die Abhängigkeit einer beobachteten quantitativen Größe von einer oder mehreren anderen (unter Berücksichtigung zufälliger Fehler) untersucht. Themen der Vorlesung sind: Einfache und multiple Regression, Theorie allgemeiner linearer Modelle, Hoch-dimensional lineare Modelle, Ausblick auf nichtlineare Modelle, Querverbindungen zur Varianzanalyse, Modelle, Residuenanalyse, Einblicke in Robuste Regression, Durchrechnung und Diskussion von Anwendungsbeispielen.

- **Prerequisites / notice**
  This is the course unit with former course title "Regression". Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

**Mathematical Finance**

- **Abstract**
  Advanced course on mathematical finance:
  - semimartingales and general stochastic integration
  - absence of arbitrage and martingale measures
  - fundamental theorem of asset pricing
  - option pricing and hedging
  - hedging duality
  - optimal investment problems
  - additional topics
  
  Topics include:
  - semimartingales and general stochastic integration
  - absence of arbitrage and martingale measures
  - fundamental theorem of asset pricing
  - option pricing and hedging
  - hedging duality
  - optimal investment problems
  - and probably others

- **Objective**
  Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes).

- **Content**
  This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

- **Literature**
  While there are many textbooks on mathematical finance, none of them is ideal to cover the contents of this course. References include the following books:

- **Prerequisites / notice**
  Prerequisites are the standard courses
  - Probability Theory (for which lecture notes are available)
  - Brownian Motion and Stochastic Calculus (for which lecture notes are available)
  Those students who already attended “Introduction to Mathematical Finance” will have an advantage in terms of ideas and concepts.

  This course is the second of a sequence of two courses on mathematical finance. The first course “Introduction to Mathematical Finance” (MF I), 401-3888-00, focuses on models in finite discrete time. It is advisable that the course MF I is taken prior to the present course, MF II.

  For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imsf/education/education-in-stochastic-finance/overview-of-courses.html.
Abstract
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature

Prerequisites / notice
Solid background in linear algebra.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Mathematics of Data Science
Abstract
Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

Objective
Introduction to various mathematical aspects of Data Science.

Content
These topics lie in overlaps of Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Most lectures will feature Mathematical Open Problems. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

Lecture notes

Prerequisites / notice
The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Bachelor Core Courses: Pure Mathematics

Further restrictions apply, but in particular:
401-3531-00L Differential Geometry I can only be recognised for the Master Programme if 401-3532-00L Differential Geometry II has not been recognised for the Bachelor Programme.

Analogously for:
401-3461-00L Functional Analysis I - 401-3462-00L Functional Analysis II
401-3001-61L Algebraic Topology I - 401-3002-12L Algebraic Topology II
401-3132-00L Commutative Algebra - 401-3146-12L Algebraic Geometry
For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-3461-00L</td>
<td>Functional Analysis I</td>
<td>E-</td>
<td>9 credits</td>
<td>4V+1U</td>
<td>M. Burger</td>
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</table>

401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

At most one of the three course units (Bachelor Core Courses) can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract
Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed graph theorem; spectral theory of self-adjoint operators in Hilbert spaces. Basics of Sobolev spaces.

Objective
Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of Linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature
Recommended references include the following:


Prerequisites / notice
Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH. Most importantly: fluency with point set topology and measure theory, in part. Lebesgue integration and L^p spaces.

Competencies

401-3531-00L Differential Geometry I

At most one of the three course units (Bachelor Core Courses) can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract
Introduction to differential manifolds and differential geometry.

Objective
Learn to compute, describe, prove, and solve problems in the language of differential geometry.

Content
Submanifolds of R^n, immersions, submersions, and embeddings, Sard's Theorem, abstract differentiable manifolds, charts, vector fields and flows, vector bundles, tensor fields, covariant derivatives, parallel transport, Riemannian metrics, geodesics, Riemann curvature tensor. Complete manifolds, Hopf-Rinow theorem. Many examples including curves, surfaces, hyperbolic space, S^3, the unit quaternions, the Gauss-Bonnet theorem, etc.

Literature
John M. Lee: Introduction to Smooth Manifolds
John M. Lee: Introduction to Riemannian Manifolds

This following books were inherited from before. The only one I know is doCarmo.

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie, Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Competencies

Table:

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<tr>
<th>Competencies</th>
<th>Techniques and Technologies</th>
<th>Analytical Competencies</th>
<th>Problem-solving</th>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
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<td>Method-specific Competencies</td>
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Further restrictions apply, but in particular:

Quantum Mechanics I is eligible as an applied core course, but only if 402-0224-00L Theoretical Physics (offered for the last time in FS 2016) isn't recognised for credits (neither in the Bachelor's nor in the Master's programme).

For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

More details on the Bachelor Core Courses:

**401-3601-00L Probability Theory**

- **Number**: 401-3601-00L
- **Title**: Probability Theory
- **ECTS**: 9 credits
- **Hours**: 4V+1U
- **Lecturers**: V. Tassion

**Abstract**
Basics of probability theory and the theory of stochastic processes in discrete time

**Objective**
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
- measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

**Content**
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
- measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

**Literature**
- H. Bauer, Probability Theory, de Gruyter 1996
- J. Jacod and P. Protter, Probability essentials, Springer 2004
- D. Williams, Probability with martingales, Cambridge University Press 1991

**Prerequisites / notice**
- Measure Theory
- Basic notions in probability theory (probability space, conditional probability, Borel Cantelli, Dynkin Lemma, random variables, expectation, variance, law of large numbers).

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Techniques and Technologies: assessed
- Creative Thinking: assessed

**402-0205-00L Quantum Mechanics I**

- **Number**: 402-0205-00L
- **Title**: Quantum Mechanics I
- **ECTS**: 8 credits
- **Hours**: 3V+2U
- **Lecturers**: M. Krstic Marinkovic

**Abstract**

**Objective**
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

**Content**
The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.

**Lecture notes**
- Auf Moodle

**Literature**
- G. Baym, Lectures on Quantum Mechanics
- E. Merzbacher, Quantum Mechanics
- L.I. Schiff, Quantum Mechanics
- R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
- J.J. Sakurai: Modern Quantum Mechanics
- A. Messiah: Quantum Mechanics I
- S. Weinberg: Lectures on Quantum Mechanics
Electives

For the Master's degree in Applied Mathematics the following additional condition (not manifest in myStudies) must be obeyed: At least 14 of the required 26 credits from core courses and electives must be acquired in areas of applied mathematics and further application-oriented fields.

Electives: Pure Mathematics

Selection: Algebra, Number Thy, Topology, Discrete Mathematics, Logic

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<tr>
<td>401-3059-00L</td>
<td>Combinatorics II W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
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</table>

Abstract
The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.

Objective
Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content
Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsdö's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

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<th>Lecturers</th>
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<tr>
<td>401-3571-74L</td>
<td>Characteristic Classes W</td>
<td>6</td>
<td>3V</td>
<td>S. Abramyan</td>
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Content
– Stiefel-Whitney classes. Applications.
– Complex vector bundles. Chern classes.
– Existence and uniqueness of Stiefel-Whitney and Chern classes.
– Cohomology of Grassmann manifolds. Chern character.
– Splitting principle. Applications of Chern classes: enumerative geometry. And if time permits:
  – Pontryagin classes.
  – Characteristic numbers and bordisms.
  – Hirzebruch genus. Divisibility of characteristic numbers.
  – Smooth structures on the 7-sphere.

Literature

Selection: Geometry

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<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>401-3057-00L</td>
<td>Finite Geometries II W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
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</table>

Abstract
Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.

Objective
Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.

Content
Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design.
Literature
- Max Jeger, Endliche Geometrien, ETH Skript 1988
- Albrecht Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983
- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press
- Dembowski: Finite Geometries.

Selection: Analysis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>401-4494-23L</td>
<td>Calculus of Variations</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>A. Dinis Bacelar Lopes Guerra</td>
</tr>
</tbody>
</table>

**Abstract**
The focus of this class is on Direct Methods in the Calculus of Variations. We will address the following topics:
1) existence of minimizers to classical variational problems;
2) regularity of minimizers to scalar and vectorial problems;
3) regularity theory for elliptic PDEs with measurable and smooth coefficients.

**Prerequisites / notice**
Functional Analysis I

**Competencies**
Subject-specific Competencies
Concepts and Theories fostered

**Selection: Further Realms and Some UZH Courses**

<table>
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<tr>
<th>Number</th>
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<th>ECTS</th>
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<tr>
<td>401-3502-72L</td>
<td>Reading Course</td>
<td>W</td>
<td>2</td>
<td>4A</td>
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</table>

**Abstract**
For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

**Selection: Numerical Analysis**

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>401-4657-00L</td>
<td>Numerical Solution of Stochastic Ordinary Differential Equations</td>
<td>W</td>
<td>6</td>
<td>3V+1U</td>
<td>C. Schwab</td>
</tr>
</tbody>
</table>
for Quantitative Finance: Monte Carlo and Sampling
Methods

Abstract
This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective
The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content
Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes
There will be English, typed lecture notes for registered participants in the course.

Literature
P. E. Kloeden and E. Platen:
Numerical Solution of Stochastic Differential Equations.

Bertoin, Jean:
Lévy processes.
x+265 pp. ISBN: 0-521-56243-0

Cont, Rama; Tankov, Peter:
Financial modelling with jump processes.

Prerequisites / notice
Prerequisites:
Mandatory:
Probability and measure theory,
basic numerical analysis and
basics of MATLAB/Python programming.

a) mandatory courses: Measure - and Probability Theory I as covered in courses:
ETH 401-2283-00L Analysis III (Measure Theory)
UZH Kursmodul 10498 Hauptvorlesung: Mass- und Integrationstheorie

b) recommended courses:
Stochastic Processes I

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

401-4785-00L Mathematical and Computational Methods in Photonics

W 7 credits 4G H. Ammari

Abstract
The aim of this course is to review new and fundamental mathematical tools, computational approaches, and inversion and optimal design methods used to address challenging problems in nanophotonics. The emphasis will be on analyzing plasmon resonant nanoparticles, super-focusing & super-resolution of electromagnetic waves, photonic crystals, electromagnetic cloaking, metamaterials, and metasurfaces...
The field of photonics encompasses the fundamental science of light propagation and interactions in complex structures, and its technological applications.

The recent advances in nanoscience present great challenges for the applied and computational mathematics community. In nanophotonics, the aim is to control, manipulate, reshape, guide, and focus electromagnetic waves at nanometer length scales, beyond the resolution limit. In particular, one wants to break the resolution limit by reducing the focal spot and confine light to length scales that are significantly smaller than half the wavelength.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare. Light-based technologies can be used effectively for the very early detection of diseases, with non-invasive imaging techniques or point-of-care applications. They are also instrumental in the analysis of processes at the molecular level, giving a greater understanding of the origin of diseases, and hence allowing prevention along with new treatments. Photonic technologies also play a major role in addressing the needs of our ageing society: from pace-makers to synthetic bones, and from endoscopes to the micro-cameras used in in-vivo processes. Furthermore, photonics are also used in advanced lighting technology, and in improving energy efficiency and quality. By using photonic media to control waves across a wide band of wavelengths, we have an unprecedented ability to fabricate new materials with specific microstructures.

The main objective in this course is to report on the use of sophisticated mathematics in diffractive optics, plasmonics, super-resolution, photonics crystals, and metamaterials for electromagnetic invisibility and cloaking. The book merges highly nontrivial multi-disciplines in order to make a breakthrough in the field of mathematical modelling, imaging, and optimal design of optical nanodevices and nanostructures capable of light enhancement, and of the focusing and guiding of light at a subwavelength scale. We demonstrate the power of layer potential techniques in solving challenging problems in photonics, when they are combined with asymptotic analysis and the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions.

In this course we shall consider both analytical and computational matters in photonics. The issues we consider lead to the investigation of fundamental problems in various branches of mathematics. These include asymptotic analysis, spectral analysis, mathematical imaging, optimal design, stochastic modelling, and analysis of wave propagation phenomena. On the other hand, deriving mathematical foundations, and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena. An emphasis is put on mathematically analyzing plasmon resonant nanoparticles, diffractive optics, photonic crystals, super-resolution, and metamaterials.

### 401-4656-21L
**AI in the Sciences and Engineering**

**Objective**

Learning objectives:

- Aware of advanced applications of AI in the sciences and engineering
- Familiar with the design, implementation, and theory of these algorithms
- Understand the pros/cons of using AI and deep learning for science
- Understand key scientific machine learning concepts and themes

**Content**

A selection of the following topics will be presented in the lectures:

1. Key scientific tasks common to many scientific domains, such as simulation, inverse problems, equation discovery, design, and control problems, and issues with traditional methods for solving them
2. Physics-informed neural networks for solving forward, inverse and equation discovery problems related to PDEs
3. Neural operators, including Fourier neural operators and DeepONets, for learning efficient surrogate models, and their theoretical foundations
4. Differentiable scientific algorithms, neural differential equations, and the benefits of hybrid workflows
5. AI for symbolic regression and equation discovery
6. Applications of graph neural networks in science
7. Guest lectures on AI for chemistry and biology
8. Large language models and other Foundation models for scientific discovery

Applications using these techniques will be illustrated across fluid dynamics, wave physics, medical physics, molecular design, and computational biology. Several examples where AI algorithms outperform traditional scientific workflows will be shown.

**Lecture notes**

Lecture slides, recordings, and tutorials will be available on Moodle.

**Literature**

All the material in the course is based on research articles written in last 1-3 years. The relevant references will be provided.

**Prerequisites / notice**

- An understanding of basic ML concepts including supervised learning, overfitting/underfitting, optimisation, and neural networks is required; you should understand the main concepts in the ETH 252-0220-00L Introduction to Machine Learning course (but note, completing this course is not a formal requirement)
- Familiar with PDEs and numerical methods for solving them
- Basic competence in Python and some practical familiarity with deep learning frameworks (e.g. PyTorch, TensorFlow, or Keras)

**Competencies**

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

**401-4652-23L**

**Inverse Problems**

**Objective**

Inverse problems arise in many applications in science & engineering. Typically, a physical model describes a forward problem and the task is to reconstruct from measurements, i.e. to perform inversion. In ill-posed problems, these inversions are troublesome as the inverse lacks e.g. stability. Regularization theory studies the controlled extraction of information from such systems.
Objective
The goal of this course is to give an understanding of ill-posedness and how it arises and to introduce the theory of regularization, which gives a mathematical framework to handle these delicate systems.

Content
Linear inverse problems, compact operators and singular value decompositions, regularization of linear inverse problems, regularization penalties, regularization parameters and parameter choice rules, iterative regularization schemes and stopping criteria, non-linear inverse problems.

Lecture notes
The lecture notes will be made available during the semester.

Literature

Prerequisites / notice
Analysis, linear algebra, numerical analysis, ideal but not necessary: functional analysis

Competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving

Personal Competencies
Creative Thinking
Critical Thinking

Syllabus

Selection: Bayesian Statistics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3823-74L</td>
<td>Markov Processes</td>
<td>W</td>
<td>3</td>
<td>1V</td>
<td>R. S. Gvalani</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This course is meant to serve as an introduction to the theory of Markov processes on finite or countable state spaces. We will discuss what a Markov process is along with associated concepts such as transition probabilities, recurrence, transience, ergodicity, reversibility etc. We will motivate various abstract notions introduced with concrete examples from physics and statistics.</td>
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<td>I. Discrete-time Markov processes, i.e. Markov chains, e.g. the random walk on the integers</td>
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<td>II. Transition probabilities and Doeblin's theorem</td>
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<td>III. Stationary probabilities and ergodic properties</td>
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<td>IV. Continuous-time Markov processes, e.g. the Poisson process</td>
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<td>V. Reversibility</td>
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<tr>
<td></td>
<td>An Introduction to Markov Processes: Daniel W. Stroock</td>
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<td>Prerequisites / notice</td>
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<td>Probability and Statistics</td>
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<td>Recommended: Analysis III (measure theory)</td>
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<td>Social Competencies</td>
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<td>Self-presentation and Social Influence</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<tr>
<td>401-3628-14L</td>
<td>Bayesian Statistics</td>
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<td>Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayesian tests and model selection, empirical Bayes, Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods.</td>
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<td>Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.</td>
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<td>Topics that we will discuss are:</td>
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<td>Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)</td>
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<td>Lecture notes</td>
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<td>A script will be available in English.</td>
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<td>Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.</td>
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<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>L. Meier</td>
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<td></td>
<td>Abstract</td>
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<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.</td>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.</td>
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<td>Techniques and Technologies</td>
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Data: 02.07.2024 12:39
Autumn Semester 2024
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"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

Knowledge of methods and basic theory for high-dimensional statistical inference

Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling


The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

401-3627-00L High-Dimensional Statistics W 4 credits 2V not available

401-4632-15L Causality W 5 credits 3G J. Peters

401-4623-00L Time Series Analysis W 4 credits 2G F. Balabdaoui
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:

Stationarity
Autocorrelation
Trend estimation
Elimination of seasonality
Spectral analysis, spectral densities
Forecasting

401-3612-00L Stochastic Simulation

Abstract
This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

Objective
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

Content
Examples of simulations in different fields (computer science, statistics, statistical mechanics, operations research, financial mathematics).


Lecture notes
A script will be available in English.

Literature


Prerequisites / notice
Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

Selection: Financial and Insurance Mathematics

In the Master's programme in Mathematics (direction Mathematics resp. Applied Mathematics 401-3013-01L Mathematical Foundations for Finance is eligible as an elective course, applied elective course, but only if 401-3988-00L Introduction to Mathematical Finance isn't recognised for credits (neither in the Bachelor's nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Number Title Type ECTS Hours Lecturers

401-3925-00L Non-Life Insurance: Mathematics and Statistics W 8 credits 4V+1U M. V. Wüthrich

Abstract
Does not take place this semester.

Objective
The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.

Content
The following topics are treated:
Collective Risk Modeling
Claim Counts Models
Individual Claim Size Modeling
Censoring and Truncation
Approximations for Compound Distributions
Ruin Theory in Discrete Time
Premium Calculation Principles
Tariffication
Generalized Linear Models and Neural Networks
Bayesian Models and Credibility Theory
Claims Reserving
Solvency Considerations

Lecture notes
M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics
http://ssrn.com/abstract=2319328

Literature
M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications

Prerequisites / notice
The exams ONLY take place during the official ETH examination period (no semester end exams), and only in person exams (i.e. no remote exams).

This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Method-specific Competencies

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>W</th>
<th>4 credits</th>
<th>2V</th>
<th>T. J. Peter</th>
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</thead>
<tbody>
<tr>
<td>401-3927-00L</td>
<td>Mathematical Modelling in Life Insurance</td>
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<tr>
<td>Abstract</td>
<td>The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.</td>
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<td>Objective</td>
<td>The course's objective is to provide the students with the understanding and the tools to create mortality tables on their own. Additionally, students should learn the basics of survival analysis.</td>
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<td>Content</td>
<td>Following main topics are covered:</td>
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<td></td>
<td>- Determining raw mortality rates</td>
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<td></td>
<td>- Smoothing techniques</td>
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<td>- Trends in mortality rates</td>
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<td>- Integration of safety margins</td>
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<td></td>
<td>- Stochastic mortality model due to Lee and Carter</td>
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<td></td>
<td>- Neural network extension of the Lee-Carter model</td>
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<td>- Machine learning for mortality forecasts</td>
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<td></td>
<td>- Survival analysis</td>
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<tr>
<td>Lecture notes</td>
<td>Lectures notes and slides will be provided</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The exams ONLY take place during the official ETH examination period.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<tr>
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<th>2V+1U</th>
<th>P. Cheridito</th>
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<tbody>
<tr>
<td>401-3915-73L</td>
<td>Machine Learning in Finance and Insurance</td>
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<tr>
<td>Abstract</td>
<td>This course introduces machine learning methods that can be used in finance and insurance applications.</td>
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<tr>
<td>Objective</td>
<td>The goal is to learn methods from machine learning that can be used in financial and insurance applications.</td>
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<tr>
<td>Content</td>
<td>Linear, polynomial, logistic, ridge and lasso regression, dimension reduction methods, singular value decomposition, kernel methods, support vector machines, classification and regression trees, random forests, XGBoost, neural networks, stochastic gradient descent, autoencoders, graph neural networks, transformers, credit analytics, pricing, hedging, insurance claim prediction.</td>
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<tr>
<td>Lecture notes</td>
<td>Course material is available on <a href="https://people.math.ethz.ch/~patrickc/mlfi">https://people.math.ethz.ch/~patrickc/mlfi</a></td>
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<td>Competencies</td>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<tr>
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<th>2G</th>
<th>M. Mayer, C. Lorentzen-Geiser</th>
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<tr>
<td>401-3931-00L</td>
<td>Responsible Machine Learning with Insurance Applications</td>
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<tr>
<td>Abstract</td>
<td>This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.</td>
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<tr>
<td>Objective</td>
<td>The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.</td>
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<tr>
<td>Content</td>
<td>• Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)</td>
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<td>• Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)</td>
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<td></td>
<td>• Bias/calibration assessment with identification functions</td>
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<td></td>
<td>• Model comparison with consistent scoring functions</td>
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<td></td>
<td>• Working with dependent observations and further topics</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This course will be held in English and counts towards the diploma of &quot;Aktuar SAV&quot;. For the latter, see details under <a href="http://www.actuaries.ch">www.actuaries.ch</a>.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Good knowledge in statistics/probability theory, statistical modelling and Python (or R) programming are assumed.</td>
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### 402-0843-00L Quantum Field Theory I

**Title:** Quantum Field Theory I

**ECTS:** 10

**Hours:** 4V+2U

**Lecturers:** L. Senatore

**Abstract:**
This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity. Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

**Objective:**
The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore, it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

**Lecture notes:**
Will be provided as the course progresses

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### 402-0861-00L Statistical Physics

**Title:** Statistical Physics

**ECTS:** 10

**Hours:** 4V+2U

**Lecturers:** M. Sigrist

**Abstract:**
This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons, and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena, and superfluidity.

**Objective:**
This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics.

**Content:**
Kinetic approach to statistical physics: H-theorem, detailed balance and equilibrium conditions.
Classical statistical physics: microcanonical ensembles, canonical ensembles and grandcanonical ensembles, applications to simple systems.
Quantum statistical physics: density matrix, ensembles, Fermi gas, Bose gas (Bose-Einstein condensation), photons and phonons. Identical quantum particles: many body wave functions, second quantization formalism, equation of motion, correlation functions, selected applications, e.g. Bose-Einstein condensate and coherent state, phonons in elastic media and melting.
One-dimensional interacting systems.
Phase transitions: mean field approach to Ising model, Gaussian transformation, Ginzburg-Landau theory (Ginzburg criterion), self-consistent field approach, critical phenomena, Peierls’ arguments on long-range order.

**Lecture notes:**
Lecture notes available in English.

**Literature:**
No specific book is used for the course. Relevant literature will be given in the course.

**Prerequisites / notice:**
Knowledge in basic thermodynamics and quantum mechanics.

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### 402-0830-00L General Relativity

**Title:** General Relativity

**ECTS:** 10

**Hours:** 4V+2U

**Lecturers:** R. Renner

**Abstract:**
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.

**Objective:**
Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

**Literature**

Suggested textbooks:

- C. Misner, K. Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

**402-0822-13L Introduction to Integrability**

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<tr>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>N. Beisert</th>
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</table>

**Abstract**

This course gives an introduction to the theory of integrable systems, related symmetry algebras and efficient calculation methods.

**Objective**

Integrable systems are a special class of physical models that can be solved exactly due to an exceptionally large number of symmetries. Examples of integrable models appear in many different areas of physics including classical mechanics, condensed matter, 2d quantum field theories and lately in string- and gauge theories. They offer a unique opportunity to gain a deeper understanding of generic phenomena in a simplified, exactly solvable setting. In this course we introduce the notion and formulation of integrability in classical and quantum mechanics. We discuss various efficient methods for constructing solutions and eigenstates in these models. Finally, we elaborate on the enhanced symmetries that underly integrable models.

**Content**

- Classical Integrability
- Algebraic Methods for Integrability
- Classical Spin Chains
- Spectral Curves and Inverse Scattering
- Quantum Spin Chains
- Bethe Ansatz
- Classical and Quantum Algebra

**Literature**


**Competencies**

- Subject-specific Competencies: Concepts and Theories, assessed
- Method-specific Competencies: Analytical Competencies, assessed
- Social Competencies: Problem-solving, assessed
- Personal Competencies: Sensitivity to Diversity, fostered
- Critical Thinking, fostered

**402-0897-00L Introduction to String Theory**

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<thead>
<tr>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>J. Brödel</th>
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</table>

**Abstract**

String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

**Objective**

Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

**Content**

- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- critical dimension and no-ghost theorem
- D-branes, T-duality
- two-dimensional conformal field theories

**Literature**


**Prerequisites**

Recommended: Quantum Field Theory I (in parallel)

**Competencies**

- Subject-specific Competencies: Concepts and Theories, assessed
- Method-specific Competencies: Analytical Competencies, assessed
- Problem-solving, assessed

**Selection: Mathematical Optimization, Discrete Mathematics**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-3055-64L</td>
<td>Algebraic Methods in Combinatorics</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>not available</td>
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</table>

**Abstract**

Does not take place this semester.

**Objective**

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure $A$ one maps its elements to vectors in a linear space, and shows that the set $A$ is mapped to linearly independent vectors. It then follows that the cardinality of $A$ is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at

https://people.inf.ethz.ch/~aroeyskoe/AA23

Prerequisites / notice

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3054-14L</td>
<td>Probabilistic Methods in Combinatorics</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>B. Sudakov</td>
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<td>Abstract</td>
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<td></td>
<td>This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.</td>
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<td></td>
<td>Content</td>
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<td>The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.</td>
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<td></td>
<td>Literature</td>
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<td></td>
<td>- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.</td>
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<tr>
<td>Prerequisites / notice</td>
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<td></td>
<td>Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.</td>
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### Lectures

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely. Students are expected to have a mathematical background and should be able to write rigorous proofs.
Objective

The fundamentals of Information Theory including Shannon's source coding and channel coding theorems.

Content

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity.

Literature

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Selection: Further Realms and Some UZH Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tr>
<td>401-3502-72L</td>
<td>Reading Course</td>
<td>W</td>
<td>2</td>
<td>4A</td>
<td>Supervisors</td>
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<td>To start an individual reading course, contact an authorised supervisor <a href="https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf">link</a> and register your reading course in myStudies.</td>
<td>[401-3502-72L] Reading Course</td>
<td>W</td>
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<td>Abstract</td>
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<td>For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.</td>
<td>[401-3502-72L] Reading Course</td>
<td>W</td>
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<td>4A</td>
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<tr>
<td>401-3503-72L</td>
<td>Reading Course</td>
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<td>6A</td>
<td>Supervisors</td>
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<td>To start an individual reading course, contact an authorised supervisor <a href="https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf">link</a> and register your reading course in myStudies.</td>
<td>[401-3503-72L] Reading Course</td>
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<td>6A</td>
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<td>401-3504-72L</td>
<td>Reading Course</td>
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<td>9A</td>
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<td>To start an individual reading course, contact an authorised supervisor <a href="https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf">link</a> and register your reading course in myStudies.</td>
<td>[401-3504-72L] Reading Course</td>
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<td>For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.</td>
<td>[401-3504-72L] Reading Course</td>
<td>W</td>
<td>4 credits</td>
<td>9A</td>
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<tr>
<td>401-3504-02L</td>
<td>Reading Course (No. 2)</td>
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<td>9A</td>
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<td>To start an individual reading course, contact an authorised supervisor <a href="https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf">link</a> and register your reading course in myStudies.</td>
<td>[401-3504-02L] Reading Course (No. 2)</td>
<td>W</td>
<td>4 credits</td>
<td>9A</td>
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<td>Abstract</td>
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<td>For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.</td>
<td>[401-3504-02L] Reading Course (No. 2)</td>
<td>W</td>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>C. Cotrini Jimenez</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.</td>
<td>[252-0535-00L] Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
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<td>Objective</td>
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<td>Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.</td>
<td>[252-0535-00L] Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
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<td></td>
<td>Content</td>
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<td>The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
<td>[252-0535-00L] Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
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<td>Topics covered in the lecture include:</td>
<td>[252-0535-00L] Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
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<td>Fundamentals:</td>
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<td>Bayesian Learning</td>
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<td>Computational learning theory</td>
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<td>Supervised learning:</td>
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<td>Ensembles: Bagging and Boosting</td>
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<td>Max Margin methods</td>
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<td>Neural networks</td>
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<td>Unsupervised learning:</td>
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<td>Dimensionality reduction techniques</td>
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<td>Clustering</td>
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<td>Mixture Models</td>
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<td>Non-parametric density estimation</td>
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<td>Learning Dynamical Systems</td>
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<td>Lecture notes</td>
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<tr>
<td></td>
<td>No lecture notes, but slides will be made available on the course webpage.</td>
<td>[252-0535-00L] Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
</tr>
</tbody>
</table>
This course introduces the foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Prerequisites / notice**

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

**Literature**


**Guarantees for Machine Learning**

**Abstract**

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work

- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions

- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project

- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

**Content**

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- overparameterized models generalize (statistically and converge (computationally)
- generalization of robust learning (adversarial or distribution-shift robustness)
- efficient and fair learning

**Prerequisites / notice**

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression", "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
- Social Competencies
  - Communication: assessed
- Personal Competencies
  - Creative Thinking: assessed
  - Critical Thinking: assessed

**Probabilistic Artificial Intelligence**

**Abstract**

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

**Content**

Topics covered:

- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

**Prerequisites / notice**

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.
### Neural Network Theory

**227-0423-00L**

**Title:** Neural Network Theory

**ECTS:** 4 credits

**Type:** W

**Lecturer:** H. Bölcskei

**Abstract:**

Does not take place this semester.

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

**Objective:**

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

**Content:**

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

**Lecture notes:** Detailed lecture notes are available on the course web page.

**Prerequisites / notice:** This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

---

### Projects in Topological Data Analysis

**263-4511-00L**

**Title:** Projects in Topological Data Analysis

**ECTS:** 4 credits

**Type:** W, G

**Lecturers:** P. Schnider

**Abstract:**

This seminar complements the course "Introduction to Topological Data Analysis". Students of the seminar will collaborate with students from international universities on concrete projects in topological data analysis, both theoretical and applied.

**Objective:**

Each student is expected to collaborate in an international working group with students from the partner universities. Each group works on one of the projects suggested by the lecturers, and is assigned a mentor. At the end of the semester, each working group presents their findings in a written report and an oral presentation.

**Content:**

This seminar complements the course Introduction to Topological Data Analysis. Students get to apply what they learned in the introductory course to concrete projects in the area of topological data analysis. These projects can be of theoretical nature, e.g., the design and analysis of a new algorithm, or applied, such as using methods from topological data analysis on concrete data sets.

**Prerequisites / notice:** Successful participation in the course "Introduction to Topological Data Analysis" or equivalent background in topological data analysis is required.

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### Electives (Direction Applied Mathematics MSc Only)

**Electives from applied mathematics and further application-oriented fields that are only eligible for credits for the Master's degree in Applied Mathematics.**

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<th>Number</th>
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<tbody>
<tr>
<td>151-0532-00L</td>
<td>Nonlinear Dynamics and Chaos I</td>
<td>W</td>
<td>4</td>
<td>G</td>
<td>G. Haller</td>
</tr>
</tbody>
</table>

**Abstract:**

Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

**Objective:**

This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

**Content:**

1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance
D. Possamaï

Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of sysyoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes: The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

Electives (only conditionally recognised)

In the Master's programme in Mathematics (direction Mathematics resp. Applied Mathematics 401-3913-01L Mathematical Foundations for Finance is eligible as an elective course resp. applied elective course, but only if 401-3888-00L Introduction to Mathematical Finance isn't recognised for credits (neither in the Bachelor's nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

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<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4</td>
<td>3V+2U</td>
<td>D. Possamaï</td>
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</table>

Abstract
First introduction to main modelling ideas and mathematical tools from mathematical finance

Objective
This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Content
Topics to be covered include
- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

- Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitsrechnung").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Potter book. If these pose problems, you will have a hard time during the course. So be prepared.

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<tr>
<td>701-1221-00L</td>
<td>Dynamics of Large-Scale Atmospheric Flow</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Wernli, J. Riboldi</td>
</tr>
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</table>

Abstract
This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

Objective
Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

Content
Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synopticsystem - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

Electives (only conditionally recognised)

In the Master's programme in Mathematics (direction Mathematics resp. Applied Mathematics 401-3913-01L Mathematical Foundations for Finance is eligible as an elective course resp. applied elective course, but only if 401-3888-00L Introduction to Mathematical Finance isn't recognised for credits (neither in the Bachelor's nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

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<tr>
<td>636-0017-00L</td>
<td>Computational Biology</td>
<td>W</td>
<td>6</td>
<td>3G+2A</td>
<td>T. Vaughan, C. Magnus, T. Stadler</td>
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The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments.

Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to evolutionary dynamics.

Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest.

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- J. Stelling
- N. Beerenwinkel

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

The course will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methodologies and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

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### Control and Automation

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<tr>
<td>151-0563-01L</td>
<td>Dynamic Programming and Optimal Control</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>R. D’Andrea</td>
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</table>

**Abstract**

Introduction to Dynamic Programming and Optimal Control. Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Content**

- Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

**Literature**


**Prerequisites / notice**

- Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

### Economics

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<tr>
<td>401-3929-00L</td>
<td>Financial Risk Management in Social and Pension</td>
<td>W</td>
<td>4 credits</td>
<td>2V</td>
<td>P. Blum</td>
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**Abstract**

Investment returns are an important source of funding for social and pension insurance, and financial risk is an important threat to stability. We study short-term and long-term financial risk and its interplay with other risk factors, and we develop methods for the measurement and management of financial risk and return in an asset/liability context with the goal of assuring sustainable funding.

**Objective**

Understand the basic asset-liability framework: essential principles and properties of social and pension insurance; cash flow matching, duration matching, valuation portfolio and loose coupling; the notion of financial risk; long-term vs. short-term risk; coherent measures of risk.

Understand the conditions for sustainable funding: derivation of required returns; interplay between return levels, contribution levels and other parameters; influence of guaranteed benefits.

Understand the notion of risk-taking capability: capital process as a random walk; measures of long-term risk and relation to capital; short-term solvency vs. long-term stability; effect of embedded options and guarantees; interplay between required return and risk-taking capability.

Be able to study empirical properties of financial assets: the Normal hypothesis and the deviations from it; statistical tools for investigating relevant risk and return properties of financial assets; time aggregation properties; be able to conduct analysis of real data for the most important asset classes.

Understand and be able to carry out portfolio construction: the concept of diversification; limitations to diversification; correlation breakdown; incorporation of constraints; sensitivities and shortcomings of optimized portfolios.

Understand and interpret the asset-liability interplay: the optimized portfolio in the asset-liability framework; short-term risk vs. long-term risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Have an overall view: see the big picture of what asset returns can and cannot contribute to social security; be aware of the most relevant outcomes; know the role of the actuary in the financial risk management process.

For pension insurance and other forms of social insurance, investment returns are an important source of funding. In order to earn these returns, substantial financial risks must be taken, and these risks represent an important threat to financial stability, in the long term and in the short term.

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of

1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

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To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

**Lecture notes**

Extensive handouts will be provided. Moreover, practical examples and data sets in Excel will be made available.

**Prerequisites / notice**

- Solid base knowledge of probability and statistics is indispensable. Specialized concepts from financial and insurance mathematics as well as quantitative risk management will be introduced in the lecture as needed, but some prior knowledge in some of these areas would be an advantage.

This course counts towards the diploma of "Aktuar SAV".

The exams ONLY take place during the official ETH examination period.
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.
Literature

For students taking only the course ‘Principles of Microeconomics’ there is a shorter version of the same book:

Complementary:

Prerequisites /
notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence assessed
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered

363-0565-00L Principles of Macroeconomics

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course Moodle page contains announcements, course information and lecture slides.

Literature

This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence assessed
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

363-1021-00L Monetary Policy

Abstract
The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the differences between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real world issues.
Objective
This lecture will introduce the fundamentals of monetary economics and explain the working and impact of monetary policy. The main aim of this course is to describe and analyze the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy, the effectiveness of monetary policy actions, the differences between monetary policy rules and discretionary policy, as well as institutional issues concerning central banks, transparency of monetary authorities and monetary policy in a monetary union framework. Moreover, we discuss the implementation of monetary policy in practice and the design of optimal policy.

Content
For the functioning of today’s economy, central banks and their policies play an important role. Monetary policy is the policy adopted by the monetary authority of a country, the central bank. The central bank controls either the interest rate payable on very short-term borrowing or the money supply, often targeting inflation or the interest rate to ensure price stability and general trust in the currency. This monetary policy course looks into today’s major questions related to policies of central banks. It provides insights into the monetary policy process using core economic principles and real-world examples.

Lecture notes
The course Moodle page contains announcements, course information and lecture slides.

Literature
The course will be based on chapters of:

Prerequisites / notice
Basic knowledge in international economics and a good background in macroeconomics.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Risk and Insurance Economics
W 3 credits 2G 4G H. Schernberg

Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
2) individual decision making under risk
3) models of insurance demand, risk sharing, insurance supply
4) information issues in insurance markets
5) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Literature
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1;

Further readings:

References will be given on a topic-by-topic basis during the course.
This course develops and refines tools for evaluating investments (capital budgeting), capital structure, and corporate securities. The course seeks to deepen students' understanding of the link between corporate finance theory and practice.

Objective

This course develops and refines tools for evaluating investments (capital budgeting), capital structure, and corporate securities. With respect to capital structure, we start with the famous Miller and Modigliani irrelevance proposition and then move on to study the effects of taxes, bankruptcy costs, information asymmetries between firms and the capital markets, and agency costs. In this context, we will also study how leverage affects some central financial ratios that are often used in practice to assess firms and their stock. Other topics include corporate cash holdings, the use and pricing of convertible bonds, and risk management. The latter two topics involve option pricing. With respect to capital budgeting, the course pays special attention to tax effects in valuation, including in the estimation of the cost of capital. We will also study payout policy (dividends and share repurchases). The course seeks to deepen students' understanding of the link between corporate finance theory and practice. Various cases will be assigned to help reach this objective.

Content

Topics covered

1. Capital structure: Perfect markets and irrelevance
2. Risk, leverage, taxes, and the cost of capital
3. Leverage and financial ratios
4. Payout policy: Dividends and share repurchases
5. Capital structure: Taxes and bankruptcy costs
6. Capital structure: Information asymmetries, agency costs, cash holdings
7. Valuation: DCF, adjusted present value and WACC
8. Valuation using options
9. The use and pricing of convertible bonds
10. Corporate risk management

363-1017-00L Risk and Insurance Economics W 3 credits 2G H. Schernberg

Abstract

The course covers the economics of risk and insurance, in particular the following topics will be discussed:

1) Individual decision making under risk
2) Models of insurance demand, risk sharing, insurance supply
3) Information issues in insurance markets
4) Advanced topics in microeconomics and behavioral economics
5) The macroeconomic role of insurers and insurance regulation

Objective

The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content

Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.
Information Theory I

A. Lapidoth

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMS filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Literature

Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1;

Further readings:

References will be given on a topic-by-topic basis during the course.

Competencies

Subject-specific Competencies
- Concepts and Theories
- assessed

Method-specific Competencies
- Analytical Competencies
- assessed

Personal Competencies
- Critical Thinking
- assessed

Self-direction and Self-management
- fostered

Image Processing and Computer Vision

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
227-0447-00L | Image Analysis and Computer Vision | W | 6 credits | 3+1U | E. Konukoglu, E. Erdil, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course materials, Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

Information and Communication Technology

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
227-0105-00L | Introduction to Estimation and Machine Learning | W | 6 credits | 4G | H.-A. Loeliger

Abstract
Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

Objective
Students master the basic mathematical concepts and algorithms of estimation and machine learning.

Content
Review of probability theory; basics of statistical estimation; least squares and linear estimation; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more

Lecture notes
Lecture notes will be handed out as the course progresses.

Prerequisites / notice
solid basics in linear algebra and probability theory

227-0101-00L | Discrete-Time and Statistical Signal Processing | W | 6 credits | 4G | H.-A. Loeliger

Abstract
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content
1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes
Lecture Notes

227-0417-00L | Information Theory I | W | 6 credits | 4G | A. Lapidoth

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.
### Machine Learning

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<tbody>
<tr>
<td>263-5210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>A. Krause</td>
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<td><strong>Abstract</strong></td>
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<td>This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics. The course is designed for graduate students.</td>
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<td>How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit &quot;intelligent&quot; behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.</td>
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<td>Topics covered: <strong>- Probability</strong></td>
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<td>Solid basic knowledge in statistics, algorithms and programming. The material covered in the course &quot;Introduction to Machine Learning&quot; is considered as a prerequisite.</td>
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<tr>
<td>263-3210-00L</td>
<td>Deep Learning</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>T. Hofmann</td>
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<td><strong>Abstract</strong></td>
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<td>Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.</td>
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<td>In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.</td>
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<td>This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.</td>
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<tr>
<td>252-3005-00L</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7</td>
<td>3V+3U+1A</td>
<td>R. Cottrell</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.</td>
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<td>The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.</td>
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<td><strong>Content</strong></td>
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<td>This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.</td>
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<td><strong>Literature</strong></td>
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<td>Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.</td>
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<tr>
<td>401-4656-21L</td>
<td>AI in the Sciences and Engineering</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>S. Mishra</td>
</tr>
</tbody>
</table>
Abstract
AI is having a profound impact on science by accelerating discoveries across physics, chemistry, biology, and engineering. This course aims to present a highly topical selection of AI applications across these fields. Emphasis will be placed on using AI, particularly deep learning, to understand systems modelled by PDEs, and key scientific machine learning concepts and themes will be discussed.

Objective
Learning objectives:
- Aware of advanced applications of AI in the sciences and engineering
- Familiar with the design, implementation, and theory of these algorithms
- Understand the pros/cons of using AI and deep learning for science
- Understand key scientific machine learning concepts and themes

Content
A selection of the following topics will be presented in the lectures:
1. Key scientific tasks common to many scientific domains, such as simulation, inverse problems, equation discovery, design, and control problems, and issues with traditional methods for solving them.
3. Neural operators, including Fourier neural operators and DeepONets, for learning efficient surrogate models, and their theoretical foundations.
5. AI for symbolic regression and equation discovery.
7. Guest lectures on AI for chemistry and biology.
8. Large language models and other Foundation models for scientific discovery.

Applications using these techniques will be illustrated across fluid dynamics, wave physics, medical physics, molecular design, and computational biology. Several examples where AI algorithms outperform traditional scientific workflows will be shown.

Lecture notes
Lecture slides, recordings, and tutorials will be available on Moodle.

Literature
All the material in the course is based on research articles written in last 1-3 years. The relevant references will be provided.

Prerequisites / notice
- An understanding of basic ML concepts including supervised learning, overfitting/underfitting, optimisation, and neural networks is required; you should understand the main concepts in the ETH 252-0220-00L Introduction to Machine Learning course (but note, completing this course is not a formal requirement).
- Familiar with PDEs and numerical methods for solving them.
- Basic competence in Python and some practical familiarity with deep learning frameworks (e.g. PyTorch, TensorFlow, or Keras).

Competencies
Subject-specific Competencies
- Concepts and Theories
  - assessed
  - Techniques and Technologies
    - assessed
Method-specific Competencies
- Analytical Competencies
  - assessed
- Problem-solving
  - assessed
- Project Management
  - fostered
Social Competencies
- Communication
  - fostered
- Cooperation and Teamwork
  - fostered
Personal Competencies
- Adaptability and Flexibility
  - fostered
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - fostered

Material Modelling and Simulation
Quantum Chemistry

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<th>Number</th>
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<tr>
<td>529-0003-01L</td>
<td>Advanced Quantum Chemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>M. Reiher, T. Weymuth</td>
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</table>

Abstract
Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer. Examples are:
* Operators derived from principles of relativistic quantum mechanics
* Relativistic effects + methods of relativistic quantum chemistry
* Open-shell molecules + spin-density functional theory
* New electron-correlation theories

Objective
The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. Examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.

Content
1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group

Lecture notes
A set of detailed lecture notes will be provided, which will cover the whole course.
Subject-specific Competencies

System theory sees the economy as a complex adaptive system.

A successful participant of the course is able to:

Analytical Competencies

- apply formal concepts to model economic growth and competition
- analyze macroeconomic models of business cycles, supply and demand
- identify critical conditions for stability and dynamic transitions
- formalize and solve one- and two-dimensional nonlinear models

Method-specific Competencies

- understand the importance of different modeling approaches
- formalize and solve one- and two-dimensional nonlinear models
- analyze macroeconomic models of business cycles, supply and demand
- apply formal concepts to model economic growth and competition

Concepts and Theories

What causes economic business cycles? How are limited resources, competition, and cooperation reflected in growth dynamics? To answer such questions, we combine macroeconomic models and methods of nonlinear dynamics. We study the role of bifurcations and control parameters for dynamic stability. Feedback cycles and coupled dynamics are reasons for limited predictability, instability and chaos.

Creative Thinking

Our approach to economic dynamics combines insights from different disciplines: macroeconomics studying business cycles and growth, system dynamics rooted general system theory and cybernetics, and nonlinear dynamics using applied mathematics.

Communication

We start with a comparison of different modeling approaches, to highlight the problems and challenges of system modeling. The subsequent lectures then introduce different one- and two-dimensional nonlinear models with applications in economics, such as models of supply and demand, business cycles, growth and competition. Emphasis is on the formal analysis of these models using methods from applied mathematics and tools for solving coupled differential equations.

Social Competencies

Weekly self-study tasks are used to apply the concepts introduced in the lectures. We practice how to solve nonlinear models formally and numerically and how to interpret the results.

Personal Competencies

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

Prerequisites / notice

Students should be familiar with nonlinear differential equations and should have basic programming skills. All necessary details to solve nonlinear models will be provided in the course. The course will not build on mathematical proofs, optimization, statistics, efficient numerical computation and other specialized skills.

Literature

2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997 [english version available: F. Schwabl, Advanced Quantum Mechanics]
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992

Note also the standard textbooks:

A) A. Szabo, N.S. Ostlund. Verlag, Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

Prerequisites / notice

Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

Systems Design

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>363-0541-00L</td>
<td>Economic Dynamics and Complexity</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>F. Schweitzer, L. Verginer</td>
</tr>
</tbody>
</table>

Abstract

What causes economic business cycles? How are limited resources, competition, and cooperation reflected in growth dynamics? To answer such questions, we combine macroeconomic models and methods of nonlinear dynamics. We study the role of bifurcations and control parameters for dynamic stability. Feedback cycles and coupled dynamics are reasons for limited predictability, instability and chaos.

Objective

A successful participant of the course is able to:

- understand the importance of different modeling approaches
- formalize and solve one- and two-dimensional nonlinear models
- identify critical conditions for stability and dynamic transitions
- analyze macroeconomic models of business cycles, supply and demand
- apply formal concepts to model economic growth and competition

Content

System theory sees the economy as a complex adaptive system. What does this mean for economic modeling?

We focus on two sources of complexity: (a) nonlinear dynamics, which is captured in this course, “Economic Dynamics and Complexity” and (b) collective interactions, which is captured in the course “Agent-Based Modeling of Economic Systems” (in Spring).

Our approach to economic dynamics combines insights from different disciplines: macroeconomics studying business cycles and growth, system dynamics rooted general system theory and cybernetics, and nonlinear dynamics using applied mathematics.

We start with a comparison of different modeling approaches, to highlight the problems and challenges of system modeling. The subsequent lectures then introduce different one- and two-dimensional nonlinear models with applications in economics, such as models of supply and demand, business cycles, growth and competition. Emphasis is on the formal analysis of these models using methods from applied mathematics and tools for solving coupled differential equations.

Theoretical Physics

In the Master's programme in Applied Mathematics 402-0205-00L Quantum Mechanics I is eligible as a course unit in the application area Theoretical Physics, but only if 402-0224-00L Theoretical Physics wasn't or isn't recognised for credits (neither in the Bachelor's nor in the Master's programme).

For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

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<tr>
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<tr>
<td>402-0809-00L</td>
<td>Introduction to Computational Physics</td>
<td>W</td>
<td>8</td>
<td>2V+2U</td>
<td>A. Adelmann</td>
</tr>
</tbody>
</table>
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and supercomputers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

**Objective**
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

**Content**
Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

**Lecture notes**
Lecture notes and slides are available online and will be distributed if desired.

**Literature**
Literature recommendations and references are included in the lecture notes.

**Prerequisites / notice**
Lecture and exercise lessons in English, exams in German or in English

**Competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
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<tr>
<td><strong>402-2203-01L Classical Mechanics</strong></td>
<td>Classical Mechanics</td>
<td>Concepts and Theories</td>
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<td></td>
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<td>Techniques and Technologies</td>
<td>fostered</td>
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<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<td>Adaptable Flexibility</td>
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<td></td>
<td>Creative Thinking</td>
<td>fostered</td>
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</tbody>
</table>

**Objective**
A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

**Content**
Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

**Lecture notes**
Lecture notes are available online.

**Literature**
No specific book is used for the course. Relevant literature will be given in the course.

**Prerequisites / notice**
Knowledge in basic thermodynamics and quantum mechanics.

**Competencies**

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<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
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<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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</table>

**Objective**
This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.

**Content**

**Lecture notes**
Lecture notes are available in English.

**Literature**
No specific book is used for the course. Relevant literature will be given in the course.

**Prerequisites / notice**
Knowledge in basic thermodynamics and quantum mechanics.

**Competencies**

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<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
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<tr>
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<td>Problem-solving</td>
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<td>Adaptability Flexibility</td>
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</table>

**Objective**
This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity. Topics include: - Relativistic quantum mechanics - Quantisation of bosonic and fermionic fields - Interactions in perturbation theory - Scattering processes and decays - Elementary processes in QED - Radiative corrections

**Lecture notes**
Will be provided as the course progresses.
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.

Objective

Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).

Content

Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, concepts such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

Literature

Suggested textbooks:

- C. Misner, K, Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

### Selective Etics - Theoretical Physics

#### Transportation Science

<table>
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<tr>
<th>Number</th>
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<tr>
<td>101-0417-00L</td>
<td>Transport Planning Methods</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>E. Heinen</td>
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</table>

### Seminars and Semester Papers

#### Seminars

NOTICE: The number of seminar places is limited, and the special selection procedure should help to allocate the places not primarily according to the registration time. Everybody is waitlisted first when he/she tries to register for such a seminar in myStudies.

Moreover: Only one mathematics seminar can be chosen per semester. In case you need to attend 2 seminars in this semester, please take contact with the Study Administration (email: studiensekretariat@math.ethz.ch).

Notice also the course unit 401-0002-99L Generic Seminar - Second Priority / Third Priority.
<table>
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<tr>
<th>Number</th>
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<td>401-3650-74L</td>
<td>Port-Hamiltonian Systems: Mathematical Aspects</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>R. Hiptmair, further speakers</td>
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<tr>
<td>401-3940-74L</td>
<td>Student Seminar on Mathematics and Data Science: Statistical-to-Computational Gaps</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>A. Bandeira, further speakers</td>
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<td>401-3620-74L</td>
<td>Student Seminar in Statistics: ...</td>
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<td>4</td>
<td>2S</td>
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<td>401-3420-70L</td>
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<td>401-3140-74L</td>
<td>Student Seminar in Numerical Algebraic Geometry</td>
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<tr>
<td>401-3050-72L</td>
<td>Student Seminar in Combinatorics</td>
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</table>

**Abstract**

The seminar covers theory and applications of port-Hamiltonian system models based on current literature. The various topics have to be presented by groups of students.

**Objective**

Participants of the seminar should acquire familiarity with the concept of port-Hamiltonian systems and the relevant mathematical theory for their analysis. They should be enabled to devise and understand port-Hamiltonian models of physical systems.

**Content**

Port-Hamiltonian systems are ubiquitous nowadays, used in areas like mechanics, fluid dynamics, thermodynamics, and (electric) circuits. They play a big role in modern control theory and are a highly active field of theoretical and applied research. Port-Hamiltonian models are ubiquitous nowadays, used in areas like mechanics, fluid dynamics, thermodynamics, and (electric) circuits. They play a big role in modern control theory and are a highly active field of theoretical and applied research.

This seminar will study a number of monograph chapters and research papers dealing with both theoretical and application aspects of post-Hamiltonian system models.

**Topics:**

- Statistical-to-Computational Gaps
- Probability and Statistics
- Good skills in linear algebra and ordinary differential equations are required

**Preparatory meeting on**

Every presentation has to be done jointly by a group of 2-3 students with presenters selected at random. Every participant will have to present on 2-3 occasions.

**Competencies**

- Subject-specific Competencies: Concepts and Theories, Analytical Competencies, Media and Digital Technologies, Problem-solving, Communication, Cooperation and Teamwork, Customer Orientation, Critical Thinking, Self-awareness and Self-reflection
- Method-specific Competencies: fostered
- Social Competencies: fostered
- Personal Competencies: fostered

**Literature**

- Prerequisites / notice: Good skills in linear algebra and ordinary differential equations are required
- Preparatory meeting on

**Student groups will be decided and topics will be assigned during the preparatory meeting.**

Semester Papers

There are several course units “Semester Paper” that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>Abstract</td>
<td>Semester Papers help to deepen the students' knowledge of a specific subject area. Students are offered a selection of topics. These papers serve to develop the students' ability for independent mathematical work as well as to enhance skills in presenting mathematical results in writing.</td>
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Science in Perspective

Two credits are needed from the “Science in Perspective” programme with language courses excluded if three credits from language courses have already been recognised for the Bachelor's degree. see https://ethz.ch/content/dam/ethz/common/docs/weisungssammlung/files-en/science-in-perspective.pdf (Eight credits must be acquired in this category: normally six during the Bachelor's degree programme, and two during the Master's degree programme. A maximum of three credits from language courses from the range of the Language Center of the University of Zurich and ETH Zurich may be recognised. In addition, only advanced courses (level B2 upwards) in the European languages English, French, Italian and Spanish are recognised. German language courses are recognised from level C2 upwards.)

Recommended Science in Perspective (Type B) for D-MATH

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
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<td>Scientific Works in Mathematics</td>
<td>O</td>
<td>0 credits</td>
<td></td>
<td>D. Possamaï</td>
</tr>
<tr>
<td></td>
<td>Target audience: Third year Bachelor students; Master students who cannot document to have received an adequate training in working scientifically.</td>
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<tr>
<td>Abstract</td>
<td>Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)</td>
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<tr>
<td>Objective</td>
<td>Learn the basic standards of scientific works in mathematics.</td>
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<tr>
<td>Content</td>
<td>- Types of mathematical works - Publication standards in pure and applied mathematics - Data handling - Ethical issues - Citation guidelines</td>
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<td>401-2000-01L</td>
<td>Lunch Sessions – Thesis Basics for Mathematics Students</td>
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<td>401-4990-00L</td>
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<td>Only students who fulfill the following criteria are allowed to begin with their Master's thesis:</td>
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</table>
a. successful completion of the Bachelor's programme;
b. fulfilling of any additional requirements necessary to
gain admission to the Master's programme.

Successful participation in the course unit 401-2000-00L
Scientific Works in Mathematics is required.
For more information, see
https://math.ethz.ch/intranet/students/theses.html

Abstract
The master's thesis concludes the study programme. Writing up the master's thesis allows students to independently produce a major piece of work on a mathematical topic. It generally involves consulting the literature, solving any ensuing problems, and putting together the results in writing.

Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
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<td>A. Bandeira, S. Mishra, R. Pandharipande, University lecturers</td>
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<td>401-5990-00L</td>
<td>Zurich Graduate Colloquium</td>
<td>E-</td>
<td>0</td>
<td>0.5K</td>
<td>University lecturers, further speakers</td>
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<td>401-4530-00L</td>
<td>Geometry Graduate Colloquium</td>
<td>E-</td>
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<td>401-5110-00L</td>
<td>Number Theory Seminar</td>
<td>E-</td>
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<td>Ö. Imamoglu, E. Kowalski, G. Wüstholz, S. Zerbes</td>
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<td>401-5350-00L</td>
<td>Analysis Seminar</td>
<td>E-</td>
<td>0</td>
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<td>F. Da Lio, N. Hungerbühler, T. Ilmanen, L. Kobel-Keller, S. Mayboroda, J. Serra, University lecturers</td>
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<tr>
<td>401-5370-00L</td>
<td>Ergodic Theory and Dynamical Systems</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>M. Akka Ginosar, M. Einsiedler, University lecturers</td>
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<td>401-5530-00L</td>
<td>Geometry Seminar</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
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<td>401-5580-00L</td>
<td>Symplectic Geometry Seminar</td>
<td>E-</td>
<td>0</td>
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<td>P. Biran, A. Cannas da Silva</td>
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<td>401-5330-00L</td>
<td>Talks in Mathematical Physics</td>
<td>E-</td>
<td>0</td>
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<td>M. Gaberdiel, G. M. Graf, P. Hintz, T. H. Willwacher</td>
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<tr>
<td>401-5650-00L</td>
<td>Zurich Colloquium in Applied and Computational Mathematics</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>R. Alafarli, H. Ammari, R. Hiptmair, S. Mishra, C. Schwab</td>
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<td>401-5600-00L</td>
<td>Seminar on Stochastic Processes</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>A. Nikeghbali</td>
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<td>401-5620-00L</td>
<td>Research Seminar on Statistics</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>Y. Chen, N. Meinshausen, J. Peters, J. Ziegel, A. Bandeira, R. Furrer, T. Höthorn</td>
</tr>
</tbody>
</table>

Objective
See how statistical methods are applied in practice.

Content
There will be about 3 talks on how statistical methods are applied in practice.

Prerequisites / notice
This is no lecture. There is no exam and no credit points will be awarded. The current program can be found on the web: http://stat.ethz.ch/events/zukost

Course language is English or German and may depend on the speaker.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered
Method-specific Competencies
Decision-making fostered
Problem-solving fostered
Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

Abstract
About 3 talks on applied statistics.
401-5910-00L  Talks in Financial and Insurance Mathematics  E-  0 credits  1K  B. Acciaio, P. Cheridito, D. Possamaï, J. Teichmann

Abstract  Regular research talks on various topics in mathematical finance and actuarial mathematics

401-5960-00L  Colloquium on Mathematics, Computer Science, and Education  E-  0 credits  N. Hungerbühler, M. Akveld, D. Grawehr Morath, D. Komm, P. Spindler

Abstract  Didactics colloquium

402-0101-00L  The Zurich Physics Colloquium  E-  0 credits  S. Huber, A. Refregier, University lecturers

Abstract  The goal of this event is to bring you closer to current day research in all fields of physics. In each semester we have a set of distinguished speakers covering the full range of topics in physics. As a participating student should learn how to follow a research talk. In particular, you should be able to extract key points from a colloquium where you don't necessarily understand every detail that is presented.

402-0800-00L  The Zurich Theoretical Physics Colloquium  E-  0 credits  J. Renes, University lecturers

Abstract  The Zurich Theoretical Physics Colloquium is jointly organized by the University of Zurich and ETH Zurich. Its mission is to bring both students and faculty with diverse interests in theoretical physics together. Leading experts explain the basic questions in their field of research and communicate the fascination for their work.

251-0100-00L  Computer Science Colloquium  E-  0 credits  Lecturers

Abstract  Invited talks, covering the entire scope of computer science. External Listeners are welcome at no charge. A detailed schedule is published at the beginning of each semester.

Objective  Top international computer scientists take the floor at the distinguished computer science colloquium. Our guest speakers present impacting topics across various areas of the discipline. The colloquium series is held every semester and also includes inaugural and farewell lectures of the department's professors. The colloquium is a noteworthy event for all graduate students. Outside attendance is equally welcome.

Content  Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>
| 406-2004-AAL | Algebra II  
*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*  
*Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.* | E-   | 6 credits | 13R | Ö. Imamoglu |
|              | Abstract                  |      |      |       |           |
|              | Galois theory and related topics. |      |      |       |           |
|              | Objective                 |      |      |       |           |
|              | The precise content changes with the examiner. Candidates must therefore contact the examiner in person before studying the material. |      |      |       |           |
|              | Content                   |      |      |       |           |
|              | The main topic is Galois Theory. Starting point is the problem of solvability of algebraic equations by radicals. Galois theory solves this problem by making a connection between field extensions and group theory. Galois theory will enable us to prove the theorem of Abel-Ruffini, that there are polynomials of degree 5 that are not solvable by radicals, as well as Galois' theorem characterizing those polynomials which are solvable by radicals. |      |      |       |           |
|              | Literature                |      |      |       |           |
|              | Or: Chapters I to III, that is, Sections 1-16 of the book Patrick Morandi: Field and Galois Theory, Springer 1996  
|              | Prerequisites / notice    |      |      |       |           |
|              | Algebra I, in Rotman's book this corresponds to the topics treated in the Chapters A3 and A4. |      |      |       |           |
|              | Competencies              |      |      |       |           |
|              | Subject-specific Competencies |  Concepts and Theories | assessed | | |
|              |                          |  Techniques and Technologies | assessed | | |
| 406-2005-AAL | Algebra I and II  
*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*  
*Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.* | E-   | 12 credits | 26R | Ö. Imamoglu, L. Halbeisen |
|              | Abstract                  |      |      |       |           |
|              | Introduction and development of some basic algebraic structures - groups, rings, fields including Galois theory, representations of finite groups, algebras. |      |      |       |           |
|              | The precise content changes with the examiner. Candidates must therefore contact the examiner in person before studying the material. |      |      |       |           |
Content

Basic notions and examples of groups:
- Subgroups, Quotient groups and Homomorphisms,
- Group actions and applications

Basic notions and examples of rings:
- Ring Homomorphisms,
- ideals, and quotient rings, rings of fractions
- Euclidean domains, Principal ideal domains, Unique factorization domains

Basic notions and examples of fields:
- Field extensions, Algebraic extensions, Classical straight edge and compass constructions

Fundamentals of Galois theory
- Representation theory of finite groups and algebras

Literature

Joseph J. Rotman, "Advanced Modern Algebra" third edition, part 1,
Graduate Studies in Mathematics, Volume 165
American Mathematical Society

406-2303-AAL Complex Analysis
- Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, conformal mappings, Riemann mapping theorem.

Literature

E.Hille: Analytic Function Theory. AMS Chelsea Publication

406-2554-AAL Topology
- Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Topological spaces, continuous maps, connectedness, compactness, metric spaces, quotient spaces, homotopy, fundamental group and covering spaces, van Kampen Theorem.

Literature
Jänich: Topology

Hatcher: Algebraic Topology

406-2604-AAL Probability and Statistics
- Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
- Probability spaces
- Discrete models, Random walk
- Conditional probabilities, Independence
- Continuous models
- Limit theorems
- Methods of moments
- Maximum likelihood estimation
- Hypothesis testing
- Confidence intervals
- Introductory Bayesian statistics
- Linear regression model

Objective
The first part of the course gives an overview of the main concepts needed to understand probability theory (sample spaces, discrete models, random walk, continuous models and limit theorems such as the Laws of Large Numbers and the Central limit theorem). It will be based on the German script "Wahrscheinlichkeitsrechnung und Statistik".

The second part covers some fundamental results of mathematical statistics including estimation methods, hypothesis testing as well as the linear regression model. For this part, we will use the script "Statistics for Mathematics". Both scripts are available at https://www.stat.math.ethz.ch/~fadouab/

Content
- Probability:
  - Chapters 1-5 (Probabilities and events, Discrete and continuous random variables, Generating functions) and Sections 7.1-7.5 (Convergence of random variables) from the book "Probability and Random Processes". Most of this material is also covered in Chap. 1-5 of "Mathematical Statistics and Data Analysis", on a slightly easier level.

- Statistics:
  - Sections 8.1 - 8.5 (Estimation of parameters), 9.1 - 9.4 (Testing Hypotheses), 11.1 - 11.3 (Comparing two samples) from "Mathematical Statistics and Data Analysis".
Lecture notes

(*) Wahrscheinlichkeitsrechnung und Statistik

(*) Statistics for Mathematics

Both scripts can be found at

https://www.stat.math.ethz.ch/~fadouab/

Literature


A. Irle, Wahrscheinlichkeitstheorie und Statistik, Teubner (2001)

401-2003-AAL Algebra I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Prerequisites / notice

The precise content changes with the examiner. Candidates must therefore contact the examiner in person before studying the material.

401-2283-AAL Analysis III (Measure Theory)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

401-2464-AAL Analysis IV (Fourier Theory and Hilbert Spaces)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

401-2465-AAL Analysis III and IV (Measure Theory / Fourier Theory and Hilbert Spaces)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

401-2334-AAL Mathematical Methods of Physics II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Mathematics Master - Key for Type

| O | Compulsory
| W+ | Eligible for credits and recommended
| W | Eligible for credits
| E- | Recommended, not eligible for credits
| Z | Courses outside the curriculum
| Dr | Suitable for doctorate

Key for Hours

| V | lecture
| G | lecture with exercise
| U | exercise
| S | seminar
| K | colloquium
| P | practical/laboratory course
| A | independent project
| D | diploma thesis
| R | revision course / private study

Special students and auditors need special permission from the lecturers.

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## Micro- and Nanosystems Master

### Core Courses

#### Devices and Systems

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>T. Jang</td>
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</table>

**Abstract**
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

**Objective**
Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

**Content**
- Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc.
- Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.
- The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

**Lecture notes**
Handouts of presented slides. No script but an accompanying textbook is recommended.

**Literature**

## Energy Conversion and Quantum Phenomena

### Devices and Systems

<table>
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<tr>
<th>Number</th>
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<td>151-0913-00L</td>
<td>Introduction to Photonics</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>R. Quidant, J. Ortega Arroyo</td>
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**Abstract**
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

**Objective**
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel coefficients
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Applications of optical tweezers

VII- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed
assessed

Method-specific Competencies
Analytical Competencies
assessed

Personal Competencies
Creative Thinking
assessed

Critical Thinking
assessed

402-0468-15L Nanomaterials for Photonic Devices W 6 credits 2V+1U R. Grange, E. Bailly, R. Chapman, V. Falcone, A. Morandi

Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, photonic integrated circuits, ordered and disordered structures,...). It starts with concepts of light-matter interactions, fabrication and characterization, the description of the properties and the state-of-the-art applications and devices.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based,...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.
Content

1. Introduction to nanophotonics
2. Wave physics for nanophotonics
3. Characterization of nanomaterials
4. Semiconductors
5. Nonlinear crystals
6. Photonic integrated circuits
7. Optical quantum devices
8. Plasmonics
9. Metasurfaces
10. Graphene & 2D Materials
11. Nanocomposites

Lecture notes

Slides and book chapter will be available for downloading

Literature

References will be given during the lecture

Prerequisites / notice

Basics of solid-state physics (i.e. energy bands) can help

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: fostered
- Decision-making: fostered

Social Competencies

- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered

Personal Competencies

- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

402-0595-00L Semiconductor Nanostructures 6 credits 2V+1U T. M. Ihn

Abstract

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

Objective

At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

Content

1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

Lecture notes


Literature

In addition to the lecture notes, the following supplementary books can be recommended:


Prerequisites / notice

The lecture is suitable for all physics students, students of Quantum Engineering, and students of Micro- and Nanosystems beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitioned students in the third year of Physics may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.
### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

**Social Competencies**
- Communication
- Self-presentation and Social Influence
- Sensitivity to Diversity

**Personal Competencies**
- Creative Thinking
- Critical Thinking

### Material, Surfaces and Properties

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Ahmed</td>
</tr>
</tbody>
</table>

**Abstract**
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

**Objective**
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

**Content**
- Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity
- Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices

**Lecture notes**

**Prerequisites / Notice**
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: fostered
  - Media and Digital Technologies: fostered
  - Problem-solving: assessed
  - Project Management: fostered
- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: fostered
  - Leadership and Responsibility: fostered
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: fostered
  - Negotiation: fostered
- Personal Competencies
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-direction and Self-management: assessed

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tbody>
<tr>
<td>151-0524-00L</td>
<td>Continuum Mechanics I</td>
<td>W+</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>A. Ehret</td>
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</tbody>
</table>

**Abstract**
The lecture deals with constitutive models that are relevant for the design and analysis of components and structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

**Objective**
After successful completion of the course students are able to
- explain basic theories for solving continuum mechanics problems
- proficiently apply these theories by solving application-related academic examples
- relate the theories and examples to real engineering applications and challenges
- distinguish between different mechanical behaviors of materials
- systematically select appropriate constitutive theories suitable to analyze and model these materials

**Content**
- Anisotropic Elasticity
- Linear Elastic and Linear Viscous Material Behavior
- Viscoelasticity, Micro-Macro Modelling
- Laminate Theory
- Plasticity, Viscoplasticity
- Examples of Engineering Applications
- Comparison with Experiments

**Lecture notes**
yes

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: fostered
  - Problem-solving: assessed
- Personal Competencies
  - Creative Thinking: fostered
  - Critical Thinking: fostered

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>327-0505-00L</td>
<td>Surfaces and Interfaces I: Fundamentals, Analytics and Applications</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>L. Isa, M. P. Heuberger</td>
</tr>
</tbody>
</table>

**Abstract**
This course teaches the basics of surface and interface science and technology, including surface modifications and forces. It covers various analytical techniques to study surface and interface properties, and explores phenomena of applied relevance like friction, lubrication, phoresis, and wetting where surfaces play a crucial role.
Objective

Students are able to
- describe the physical and chemical properties of surfaces and interfaces.
- analyze and compare analytical tools for surfaces.
- choose and combine appropriate surface-analytical approaches for solving problems connected to applications.
- understand and explain the importance of surfaces and interfaces in a broad range of phenomena and applications.

Content

- Introduction to surfaces and interfaces
- Structure of surfaces over different length scales: from macroscopic roughness to atomic structure
- Surface modifications
- Adsorption and adsorption models
- Surface forces
- Basic physical concepts
- Thermodynamics of surfaces and interfaces
- Measurement of intermolecular and surface forces
- Dynamics and history effects
- Surface analytics: X-ray Photoelectron Spectroscopy (XPS) – principles and modern developments
- Surface analytics: Secondary Ion Mass Spectroscopy (SIMS) and IR Spectroscopy – Principles and examples
- Atomic Force Microscopy (AFM): Principles and modes of operation
- Tribology: Adhesion, Friction and Lubrication
- Contact mechanics
- Micro and macroscale friction
- Boundary lubrication
- Wetting
- Contact angles
- Phoretic phenomena
- Electric double layer and electrophoresis
- Electro-osmosis
- Other types of phoresis
- Case studies

Lecture notes

Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Literature

Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Prerequisites / notice

Chemistry:
General undergraduate chemistry
including basic chemical kinetics and thermodynamics

Physics:
General undergraduate physics
including basic theory of interatomic and intermolecular forces, atomic and crystalline structure of materials and their mechanical and electronic properties

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

Modelling and Simulation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
<td>W+</td>
<td>6 credits</td>
<td>4G</td>
<td>J. Smajic</td>
</tr>
</tbody>
</table>

Abstract

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

Laboratory Course

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-0620-00L</td>
<td>Embedded MEMS Lab</td>
<td>W+</td>
<td>5 credits</td>
<td>3P</td>
<td>C. Hierold, A. Güntner, M. Haluska</td>
</tr>
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</table>

Abstract

Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report.

Objective

Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

Lecture notes
A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

Literature
The document provides sufficient information for the participants to successfully participate in the course.

Prerequisites / notice
Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Darai, Dual, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course *151-0621-00L Microsystems Technology* successfully.

Priority 3: master students, who attended the bachelor course *151-0621-00L Microsystems Technology* successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

Elective Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0409-00L</td>
<td>Multiphysics Modeling and Simulation</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>C. I. Roman</td>
</tr>
</tbody>
</table>

Abstract
This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

Objective
As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has it price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling. Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

Content
- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramp of nonlinearities and couplings
- Coupling and segregation of multiphysics

Lecture notes
Lecture handouts will be posted online.
Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies

Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

Dynamic Behavior of Materials

151-0525-00L

Lectures and computer labs concerned with the modeling of the deformation response and failure of engineering materials (metals, polymers and composites) subject to extreme loadings during manufacturing, crash, impact and blast events.

Objective

Students will learn to apply, understand and develop computational models of a large spectrum of engineering materials to predict their dynamic deformation response and failure in finite element simulations. Students will become familiar with important dynamic testing techniques to identify material model parameters from experiments. The ultimate goal is to provide the students with the knowledge and skills required to engineer modern multi-material solutions for high performance structures in automotive, aerospace and naval engineering.

Content

Topics include temperature and strain rate dependent elasto-plasticity, dynamic brittle and ductile fracture; impulse transfer, impact and wave propagation in solids; computational aspects of material model implementation; simulation of dynamic failure of structures;

Lecture notes

Slides of the lectures, relevant journal papers and user manuals will be provided.

Literature

Various books will be recommended pertaining to the topics covered.

Prerequisites / notice

Course in continuum mechanics (mandatory), finite element method (recommended)

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies

Communication fostered
Cooperation and Teamwork fostered

Personal Competencies

Creative Thinking fostered
Critical Thinking fostered

Nonlinear Dynamics and Chaos I

151-0532-00L

Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective

This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content

(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes

The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

Embedded Control Systems

151-0593-00L

This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

Objective

Familiarize students with main architectural principles and concepts of embedded control systems.
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

Lecture notes
Handouts (available online)

C. Hierold

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

Detailed information can be found on the course website
http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites / Notice</th>
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<tbody>
<tr>
<td>151-0621-00L</td>
<td>Microsystems I: Process Technology and Integration</td>
<td>W 6</td>
<td>Prerequisite courses are Control Systems I and Informatics I.</td>
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</table>

Abstract
Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and devices by the combination of unit process steps (process flow).

Objective
Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices.

Content
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

Lecture notes
Handouts (available online)

Literature
- S. M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O. Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites / notice
Prerequisites: Physics I and II

151-0642-00L Seminar on Micro and Nanosystems

Abstract
Scientific presentations from the field of Micro- and Nanosystems

Objective
In particular, the seminar addresses students, who are interested in scientific work in the field of Micro- and Nanosystem technologies, or who have started already with it. Respectively, current examples in the research will be discussed.

Content
Current themes in the field of Micro- and Nanosystem technologies using the examples of intern and extern research groups, as well as ongoing themes of study-, diplom- and doctoral thesis will be introduced and discussed. The scope of the seminar is broadened by occasional guest speakers.

Lecture notes
- 

Literature
Master of MNS, MAVT, ITET, Physics

Prerequisites / notice
- 

151-0941-00L Molecular Sensors: From Fundamentals to Health and Environmental Applications

Note: previous course title until HS23 * Molecular Health Sensors and Devices*

Abstract
Molecular sensors are used in everyday life in health care, environmental monitoring, food safety, space and other fields. Sources of molecular information, its transport and fundamental concepts of molecular sensing will be discussed. In the scope of group projects, the acquired knowledge will be applied and deepened in case studies.

Objective
After the course, the students will:

- know the requirements and merits of molecular sensors for health, environmental and other emerging applications (e.g. space)
- understand transport phenomena of molecular information & surface interactions and know how to quantitatively describe these
- understand fundamental sensing concepts for the detection and quantification of molecular analytes
- know concepts of signal processing
- be capable to apply the learnt knowledge to conceive and engineer sensor concepts and systems
- know how to investigate sensor-related literature and present scientific data

Content
Transport of Molecular Information; Surface Interactions; Sensor Fundamentals; Chemoresistive Sensing; Electrochemical Sensing; Mass-sensitive; Capacitive Sensing; Signal Processing; Medical Requirements for Molecular Sensing

Lecture notes
Hand-outs will be provided to each lecture including the exercises and their solutions.
Solid State Electronics and Optics

**Abstract**

"Solid State Electronics" is an introductory condensed matter physics course covering crystal structure, electron models, classification of metals, semiconductors, and insulators, band structure engineering, thermal and electronic transport in solids, magnetoresistance, and optical properties of solids.

**Objective**

Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.

**Prerequisites / notice**

Recommended background: Undergraduate physics, mathematics, semiconductor devices

**227-0157-00L**

Semiconductor Devices: Physical Bases and Simulation

**W** 4 credits 3G  A. Schenk, C. I. Roman

**Abstract**

The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

**Objective**

The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

**Content**

The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focused on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

**Lecture notes**

The script (in book style) can be downloaded: [https://iis-students.ee.ethz.ch/lectures/](https://iis-students.ee.ethz.ch/lectures/)

**Prerequisites / notice**


**227-0225-00L**

Linear System Theory

**W** 6 credits 5G  J. Lygeros, A. Tsiamis

**Abstract**

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

**Objective**

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

**Content**

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**227-0311-00L**

Qubits, Electrons, Photons

**W** 6 credits 3V+2U  T. Zambelli

**Abstract**

In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

**Objective**

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!).
Content

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM, while corresponding videos of the previous years are available in Moodle !!!

Literature


Supplementary material will be uploaded in Moodle.

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+ (as rigorous and profound presentation of the mathematical framework) G. Dell’Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer

+ (as account of those formidable years) G. Gamow, "Thirty Years that Shook Physics", 1985, Dover Publications Inc.

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET "Physics II".

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.


complements This lecture very well in that respect.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements This lecture very well in that respect.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1934 of 2667
Emerging Memory Technologies

This course focuses on the current state and prospects of memory technologies, emerging beyond the silicon transistor era. We explore resistive PCM and RRAM, magnetic MRAM and ferroelectric FRAM memories, covering physics, device aspects and the latest research in the field. Through interactive lectures and laboratory sessions, students gain up-to-date knowledge and compare emerging memory techs.

In this course, students will learn about the leading contenders for post-silicon storage-class and main memory technologies. Decades of research have yielded several efficient memory device working principles, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM, MTJ), and ferroelectricity (FRAM, FeFET). Currently, these memory technologies are transitioning from research to industry, and are predicted to have at least niche applications in the ever-growing hardware market. Some technologies, such as PCM, may even eventually surpass silicon-based flash memory, providing better performance and unique features.

Students will have the opportunity to compare emerging memory technologies with state-of-the-art SSD Flash, DRAM, and SRAM, as well as evaluate their potential. Through critical thinking discussions, students will acquire important skills for assessing the strengths and limitations of these emerging technologies.

The course is organized as a series of lectures, focusing on selected memory technologies. This class also includes practical laboratory sessions for the PCM research topics. Students will spend 2 hours per week in the class or laboratory and additional 2-3 hours per week to prepare for the exam.

Quantum Measurements and Optomechanics

The measurement process is at the heart of both science and engineering. Measurement precision is ultimately limited by the laws of quantum mechanics. This course provides the knowledge necessary to understand current state-of-the-art quantum measurement systems operating at their fundamental limits with a particular focus on optomechanical implementations.

The goal of this course is to understand the quantum limits of measurement precision together with a formal description of the measurement process in the framework of quantum mechanics. The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. We discuss the "standard quantum limit" as it arises from the balance of measurement imprecision and backaction, before turning to approaches to overcome it and reach the fundamental "Heisenberg limit". The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics. Exercises serve to consolidate our understanding and insight.

Lecture notes

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the theoretical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signallowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites / notice

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Creativity and Flexibility: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Abstract

Critical Thinking
Cooperation and Teamwork
Decision-making

Literature

Lecture notes will be made available on the website.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: fostered

Abstract

The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. We discuss the "standard quantum limit" as it arises from the balance of measurement imprecision and backaction, before turning to approaches to overcome it and reach the fundamental "Heisenberg limit". The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics. Exercises serve to consolidate our understanding and insight.

Prerequisites

1. Electrodynamics
2. Physics 1.2
3. Introduction to quantum mechanics
Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy. Does not take place this semester.

Objective

Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale. We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of nano-optics, which is the study of light-matter interaction at the sub-wavelength scale. The course includes a presentation by each student in which a related scientific publication is discussed. This presentation is compulsory and accounts for 30% of the grade.

Content

This course explores the exciting realm of carbon-based nanoelectronics, where the remarkable quantum properties of materials like graphene, carbon nanotubes, graphene nanoribbons, and single molecules are used for building electronic devices.

The objective of this course is to understand how the electronic properties of carbon-based materials can be exploited for fabricating quantum devices. We will delve into both the theoretical and experimental aspects, discussing how these materials’ unique properties can be translated into device functionality.

On the theoretical side, we'll cover how the chemical structure of the material and its dimensionality, ranging from 0D to 2D, affects the electronic properties. We'll also discuss how charge carriers flow through the devices and what charge transport mechanisms are at play.

On the experimental side, we'll cover how such devices are fabricated, including how the materials are synthesized. We'll also discuss how to characterize the devices and assess their performance.

The course will cover the following carbon-based materials:

- Single-molecule
- Graphene (single layer, bilayer, twisted bilayer)
- Graphene nanoribbons
- Carbon nanotubes

For each material, we will discuss:

- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

The course also includes a presentation by each student in which a related scientific publication is discussed. This presentation is compulsory and accounts for 30% of the grade.

Lecture slides are distributed every week. In addition, relevant scientific articles and book chapters will be provided for self-study.

Literature

In addition to the slides, the following supplementary books can be recommended:


Prerequisites / notice

A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Media and Digital Technologies
- Decision-making
- Problem-solving
- Communication
- Cooperation and Teamwork
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

In addition to the slides, the following supplementary books can be recommended:


Prerequisites / notice

A basic knowledge of solid-state physics and quantum mechanics is required. The course is taught in English.

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- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Prerequisites / notice

Electromagnetic fields and waves (or equivalent)

Prerequisites / notice

Physics I+II
Quantum Information Processing I: Concepts

Objective
The course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time simulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.
Introduction to experimental systems for quantum information processing (QIP).

Basic aspects of surface science. Understanding of principles of most important experimental methods used in research concerned with surface science, material science and catalysis are considered and their application is demonstrated on practical examples.

Methods which are covered embrace: Gas adsorption and surface area analysis, IR-Spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, X-ray absorption, solid state NMR, Electron Microscopy and others.

Process creation: heuristics vs. mathematical programming.


Process economic evaluation: equipment sizing and costing, time value of money, cash flow calculations.

Process integration: sequencing of distillation columns using mixed-integer linear programming (MILP), and synthesis of heat exchanger networks using mixed-integer nonlinear programming (MINLP).

Batch processes: scheduling, sizing, and inventories.

Principles of molecular design using mixed-integer programming.

- Quantum bits
  - Coherent Control
  - Measurement
  - Decoherence
- QIP with
  - Ions
  - Superconducting Circuits
  - Photons
  - NMR
  - Rydberg atoms
  - NV-centers
  - Quantum dots

Course material be made available at www.qudev.ethz.ch and on the Moodle platform for the course. More details to follow.
Literature

Main books

Other references

Prerequisites / notice
Prerequisite: Basic knowledge on unit operations, mainly reaction engineering and distillation. It is recommended that the student takes the module "Process Simulation and Flowsheeting" before "Process Design and Development", but it is not mandatory.

701-1239-00L  Aerosols I: Physical and Chemical Principles  W  4 credits  2V+1U  M. Gysel Beer, D. Bell, E. Weingartner

Abstract
Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

Objective
Physical and chemical principles:
The students...
- know the processes and physical laws of aerosol dynamics.
- understand the thermodynamics of phase equilibria and chemical equilibria.
- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:
The students...
- know the most important chemical and physical measurement instruments.
- understand the underlying chemistry and physics.

Environmental impacts:
The students...
- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
- know the most important climate impacts of atmospheric aerosols.
- are aware of the health impacts of atmospheric aerosols.

Lecture notes
Material is distributed during the lecture

Literature

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

752-3103-00L  Food Rheology  W  3 credits  2V  P. A. Fischer

Abstract
Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

Objective
The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

Content
Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

Lecture notes
Notes will be handed out during the lectures.

Literature
Provided in the lecture notes.

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## Multidisciplinary Courses

The students are free to choose individually Master’s courses from the Course Catalogue of ETH Zurich, ETH Lausanne and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Course Catalogue of ETH Zurich

## Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

## Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1007-00L</td>
<td>Semester Project Micro- and Nanosystems</td>
<td>O</td>
<td>8</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

**Abstract**
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

**Objective**
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

## Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>8</td>
<td></td>
<td>external organisers</td>
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</tbody>
</table>

**Abstract**
The main objective of the minimum twelve-week internship is to expose Master’s students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

**Objective**
The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

## Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1006-00L</td>
<td>Master's Thesis Micro- and Nanosystems</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

**Abstract**
Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

**Objective**
The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

### Micro- and Nanosystems Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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</tr>
<tr>
<td>Key for Hours</td>
<td>Description</td>
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<td>practical/laboratory course</td>
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<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Exchange Students

Courses for Exchange Students

Prepare a study plan

In case the course catalogue of the upcoming semester is not available yet, please expect it to be like the year before.

You can study at ETH Zurich as an exchange student for 1 or 2 semesters, starting in the autumn or in the spring semester.

Exchange students may choose courses from different curricula and years, provided that at least two thirds of all courses are taken in the ETH Zurich department they are registered in. Please be sure to coordinate your schedule with your home university.

Exam sessions and End-of-semester examinations

Like all ETH Zurich students, exchange students are obliged to sit their exams during the official examination periods. Students are requested to be present at ETH Zurich during these periods. You are therefore expected to plan your studies, internships, jobs, and financial means accordingly.

Research Project

The courses below are only available for exchange students.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<td>5 credits</td>
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<td></td>
<td>Any other students (e.g. BSc, MSc, doctoral students) CANNOT enrol for this course unit.</td>
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<td>900-0010-00L</td>
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<td>900-0015-00L</td>
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<td>20 credits</td>
<td>43A</td>
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<td>900-0030-00L</td>
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Additional Courses

by individual arrangement

Exchange Students - Key for Type

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<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
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<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>E</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

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<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Neural Systems and Computation Master

Core Courses

Compulsory Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1039-00L</td>
<td>Basics of Instrumentation, Measurement, and Analysis (University of Zurich)</td>
<td>O</td>
<td>4</td>
<td>9S</td>
<td>S.-C. Liu, T. Dalbrück, R. Hahnloser, G. Indiveri, V. Mante, P. Pyk, W. von der Behrens</td>
</tr>
<tr>
<td></td>
<td>Mind the enrolment deadlines at UZH:</td>
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<td></td>
<td><a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html">https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html</a></td>
</tr>
<tr>
<td></td>
<td>Registration in this class requires the permission of the instructors.</td>
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<td></td>
<td>Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.</td>
</tr>
<tr>
<td>Abstract</td>
<td>The goal of Part I is to provide a general introduction to the signal acquisition process. Students are familiarized with basic lab equipment such as oscilloscopes, function generators, and data acquisition devices. Different electrical signals are generated, visualized, filtered, digitized, and analyzed using Matlab (Mathworks Inc.) or Labview (National Instruments).</td>
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<tr>
<td>Objective</td>
<td>In Part II, the students are divided into small groups to work on individual measurement projects according to availability and interest. Students single-handedly solve a measurement task, making use of their basic knowledge acquired in the first part. Various signal sources will be provided.</td>
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</tr>
<tr>
<td>Prerequisites</td>
<td>For each part, students must hand in a written report and present a live demonstration of their measurement setup to the respective supervisor. The supervisor of Part I is the teaching assistant, and the supervisor of Part II is task specific. Admission to Part II is conditional on completion of Part I (report + live demonstration).</td>
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</tr>
<tr>
<td>Reports</td>
<td>Reports must contain detailed descriptions of the measurement goal, the measurement procedure, and the measurement outcome. Either confidence or significance of measurements must be provided. Acquisition and analysis software must be documented.</td>
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<tr>
<td>227-1031-00L</td>
<td>Journal Club (University of Zurich)</td>
<td>O</td>
<td>2</td>
<td>1S</td>
<td>G. Indiveri</td>
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<tr>
<td></td>
<td>Mind the enrolment deadlines at UZH:</td>
<td></td>
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<td></td>
<td><a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html">https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html</a></td>
</tr>
<tr>
<td>Abstract</td>
<td>The Neuroinformatics Journal club is a weekly meeting during which students present current research papers. The presentation is followed by a general discussion.</td>
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<tr>
<td>Objective</td>
<td>The Neuroinformatics Journal club aims to train students to present cutting-edge research clearly and efficiently. It leads students to learn about current topics in neurosciences and neuroinformatics, to search the relevant literature and to critically and scholarly appraise published papers. The students learn to present complex concepts and answer critical questions.</td>
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<tr>
<td>Competencies</td>
<td>Relevant current papers in neurosciences and neuroinformatics are covered.</td>
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</tr>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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</tr>
<tr>
<td>Subject-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Personal Competencies</td>
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<td>Integrity and Work Ethics</td>
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<td>227-1043-00L</td>
<td>Neuroinformatics - Colloquia (University of Zurich)</td>
<td>Z</td>
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<td>1K</td>
<td>S.-C. Liu, R. Hahnloser, V. Mante</td>
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<tr>
<td>Abstract</td>
<td>The colloquium in Neuroinformatics is a series of lectures given by invited experts. The lecture topics reflect the current themes in neurobiology and neuromorphic engineering that are relevant for our Institute.</td>
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<tr>
<td>Objective</td>
<td>The goal of these talks is to provide insight into recent research results. The talks are not meant for the general public, but really aimed at specialists in the field.</td>
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<tr>
<td>Content</td>
<td>All topics concern neural computation and their implementation in biological or artificial systems.</td>
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<td>227-1045-00L</td>
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<td>O</td>
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<td>1S</td>
<td>W. von der Behrens, R. Hahnloser, V. Mante, M. Payvand</td>
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<td>Abstract</td>
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<tr>
<td>Objective</td>
<td>The topics depend heavily on the invited speakers, and thus change from week to week.</td>
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corresponding module directly at UZH as an incoming student.
UZH Module Code: INI431

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsserv/en/studies/application/deadline s.html

Abstract
Thirteen major areas of research have been selected, which cover the key concepts that have led to our current ideas of how the nervous system is built and functions. We will read both original papers and explore the conceptual links between them and discuss the 'sociology' of science, the pursuit of basic science questions over a century of research. 

Objective
It is commonplace that scientists rarely cite literature that is older than 10 years and when they do, they usually cite one paper that serves as the representative for a larger body of work that has long since been incorporated anonymously in textbooks. Even worse, many authors have not even read the papers they cite in their own publications. This course, Foundations of Neuroscience is one antidote. Thirteen major areas of research have been selected. They cover the key concepts that have led to our current ideas of how the nervous system is built and functions. Unusually, we will explore these areas of research by reading the original publications, instead of reading a digested summary from a textbook or review. By doing this, we will learn how the discoveries were made, what instrumentation was used, how the scientists interpreted their own findings, and how their work, often over many decades and linked together with related findings from many different scientists, generate the current views of mechanism and structure of the nervous system. We will read different original papers and explore the conceptual links between them and discuss the 'sociology' of science. We will also explore the personalities of the scientists and the context in which they made their seminal discoveries. Each week, course members will be given original papers to read for homework and they will write a short abstract for each paper. We will then meet weekly with the course leader and an assistant for an hour-or-so long interactive seminar. An intimate knowledge of the papers will be assumed so that the discussion does not center simply on an explication of the contents of the papers. Assessment will be in the form of assignments throughout the semester.

Content
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Prerequisites / notice
 Restricted admission. Only open for students of the MSc program 'Neural Systems and Computation'.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

Elective Core Courses

Systems Neurosciences

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<tr>
<th>Number</th>
<th>Title</th>
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<td>227-0421-00L</td>
<td>Learning in Deep Artificial and Biological Neuronal Networks</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Grewe</td>
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Abstract
Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods. The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers. After this course students will be able to:

- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train neuronal networks
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Objective
The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes
The lecture slides will be provided as a PDF after each lecture.
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

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After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

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The lecture slides will be provided as a PDF after each lecture.

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:
1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

#### Neurotechnologies and Neuromorphic Engineering

<table>
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<tr>
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<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6</td>
<td>2V+1U+1A</td>
<td>V. Mante, B. Grewe, G. Indiveri, M. Payvand</td>
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<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu, M. Payvand</td>
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**Abstract**

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective**

Understanding of the characteristics of neuromorphic circuit elements.
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

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<td>401-0151-00L</td>
<td>Linear Algebra</td>
<td>W</td>
<td>5</td>
<td>3V+2U</td>
<td>V. C. Gradinaru</td>
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</table>
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and fostered in scientific simulations. This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.

This course provides a general introduction into electron- and ion- microscopy of organic and inorganic materials. In the first part, the methods designed to use these probes in the structural and chemical analysis of various materials. In the second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, focused ion-beam and atom probe microscopes are presented. Throughout the semester, various applications in materials science, solid state physics, structural biology, structural geology, and structural chemistry will be reported.

Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem. Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

This course provides an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell’s equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems. This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.

401-2813-00L Programming Techniques for Scientific Simulations I

Abstract
Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte

Objective
Lecture notes
Literature
K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002

Competencies

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<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Critical Thinking</td>
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402-0809-00L Introduction to Computational Physics

Abstract
This course provides an introduction into computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell’s equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems. This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.

Objective

Competencies

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327-0703-00L Electron Microscopy in Material Science

Abstract
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content
This course provides a general introduction into electron- and ion- microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, focused ion-beam and atom probe microscopes are presented. Throughout the semester, various applications in materials science, solid state physics, structural biology, structural geology, and structural chemistry will be reported.

402-0341-00L Medical Physics I

Abstract
Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.
Objective
Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a
quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are
applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline
where physics can directly be used for the benefit of patients and the society.

Content
The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons
as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte
Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionizing radiation in
simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of
ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will
be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the
clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications
in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Lecture notes
A script will be provided.

Prerequisites / Competencies
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of
the studies.

Subject- Specific Competencies Concepts and Theories
Techniques and Technologies assessed assessed

227-1047-00L Consciousness: From Philosophy to Neuroscience
(University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: INI410
Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract
This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective
features of consciousness are explored, and modern research into its neural substrate, particularly in the visual domain, is explained.
Emphasis is placed on students developing their own thinking through a discussion-centered course structure.

Objective
The course’s goal is to give an overview of the contemporary state of consciousness research, with emphasis on the contributions brought
by modern cognitive neuroscience. We aim to clarify concepts, explain their philosophical and scientific backgrounds, and to present
experimental protocols that shed light on a variety of consciousness related issues.

Content
The course includes discussions of scientific as well as philosophical articles. We review current schools of thought, models of
consciousness, and proposals for the neural correlate of consciousness (NCC).

Lecture notes
None

Literature
We display articles pertaining to the issues we cover in the class on the course’s webpage.

Prerequisites / notice
Since we are all experts on consciousness, we expect active participation and discussions!

402-0674-00L Physics in Medical Research: From Atoms to Cells
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For
quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple
metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

Abstract
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein
absorption/activity and monocyte behaviour.

Objective
As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are
presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning
tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining
the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is
characterised by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the
mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure’s
shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena
are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need
to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic
excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy
electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from
ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism
and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and
roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to
determine these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell
proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense
beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s
anisotropies of biopes.

252-0535-00L Advanced Machine Learning
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the
classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data
analysis. This course is accompanied by practical machine learning projects.

Abstract
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics
knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms
and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine
learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

**Lecture notes**
No lecture notes, but slides will be made available on the course webpage.

**Literature**

**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

**Science in Perspective**
- see Science in Perspective: Language Courses ETH/UZH
- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-ITET

**Master's Thesis and Semester Papers/Seminars**

**Option 1: Long Master's Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1041-01L</td>
<td>NSC Master's Thesis (long) and Exam (University of Zurich)</td>
<td>W</td>
<td>45</td>
<td>96D</td>
<td>M. F. Yanik</td>
</tr>
</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

**UZH Module Code: INI503**

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Only students who fulfill the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

**Abstract**
The Master thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

**Objective**
see above

**Option 2: Short Master's Thesis and Semester Papers/Seminars**

**Option 2: Short Master's Thesis and Semester Papers/Seminars**

**Short Master Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-1041-02L</td>
<td>NSC Master's Thesis (short) and Exam (University of Zurich)</td>
<td>W</td>
<td>29</td>
<td>62D</td>
<td>M. F. Yanik</td>
</tr>
</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

**UZH Module Code: INI504**

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html
Only students who fulfil the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
The Master thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective
see above

 adventurer Semester Papers/Seminars

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1036-01L</td>
<td>NSC Master Short Project I (University of Zurich)</td>
<td>W</td>
<td>8 credits</td>
<td>17A</td>
<td>M. F. Yanik</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
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<td></td>
<td>UZH Module Code: INI505</td>
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<td>Abstract</td>
<td>Usually a student selects the topic of a Master Short Project in consultation with his or her mentor.</td>
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<td>Objective</td>
<td>see above</td>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-1036-02L</td>
<td>NSC Master Short Project II (University of Zurich)</td>
<td>W</td>
<td>8 credits</td>
<td>17A</td>
<td>M. F. Yanik</td>
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<td></td>
<td>UZH Module Code: INI506</td>
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Neural Systems and Computation Master - Key for Type

| O          | Compulsory | E-  | Recommended, not eligible for credits |
| W+         | Eligible for credits and recommended | Z   | Courses outside the curriculum        |
| W          | Eligible for credits                  | Dr  | Suitable for doctorate                 |

Key for Hours

| V          | lecture | P   | practical/laboratory course            |
| G          | lecture with exercise                 | A   | independent project                    |
| U          | exercise | D   | diploma thesis                         |
| S          | seminar | R   | revision course / private study        |
| K          | colloquium |      |                                            |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MSc Nuclear Engineering is a joint program of EPF Lausanne and ETH Zurich. The first semester takes place in Lausanne. Students therefore have to enroll at EPFL.

For more information about the curriculum and courses see: [https://www.epfl.ch/education/master/programs/nuclear-engineering/](https://www.epfl.ch/education/master/programs/nuclear-engineering/)

## Core Courses

### 1. Semester (EPFL)

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-2011-00L</td>
<td>Physics of Nuclear Reactors (EPFL)</td>
<td>O</td>
<td>6</td>
<td>6G</td>
<td>external organisers</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.</td>
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<tr>
<td>Abstract</td>
<td>In this course, one acquires an understanding of the basic neutronics interactions occurring in a nuclear fission reactor and, as such, the conditions for establishing and controlling a nuclear chain reaction.</td>
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<tr>
<td>Objective</td>
<td>By the end of the course, the student must be able to:</td>
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<tr>
<td></td>
<td>- Elaborate on neutron diffusion equation</td>
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<td></td>
<td>- Systematize nuclear reaction cross sections</td>
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<td></td>
<td>- Formulate approximations to solving the diffusion equation for simple systems</td>
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<td>Content</td>
<td>Content:</td>
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<tr>
<td></td>
<td>- Brief review of nuclear physics</td>
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<td></td>
<td>- Historical: Constitution of the nucleus and discovery of the neutron</td>
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<td></td>
<td>- Nuclear reactions and radioactivity - Cross sections - Differences between fusion and fission.</td>
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<td></td>
<td>- Nuclear fission</td>
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<td></td>
<td>- Characteristics - Nuclear fuel - Introductory elements of neutronics.</td>
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<td>- Fissile and fertile materials - Breeding.</td>
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<td>- Neutron diffusion and slowing down</td>
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<td>- Monoenergetic neutrons - Angular and scalar flux</td>
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<td></td>
<td>- Diffusion theory as simplified case of transport theory - Neutron slowing down through elastic scattering.</td>
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<td>- Multiplying media (reactors)</td>
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<td>- Multiplication factors - Criticality condition in simple cases,</td>
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<td></td>
<td>- Reactor kinetics</td>
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<td>- Point reactor model: prompt and delayed transients - Practical applications.</td>
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<td></td>
<td>- Reactivity variations and control</td>
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<td></td>
<td>- Short, medium and long term reactivity changes ? Different means of control.</td>
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<tr>
<td>Literature</td>
<td>Distributed documents, recommended book chapters</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisite for: Reactor Experiments</td>
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</tbody>
</table>

| 151-2013-00L | Radiation and Reactor Experiments (EPFL)                               | O    | 6    | 4G    | external organisers        |
|              | No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL. |
| Abstract     | The reactor experiments course aims to introduce the students to radiation detection techniques and nuclear reactor experiments. The core of the course is the unique opportunity to conduct reactor experiments, as the control rod calibration, and approach to critical. |
| Objective    | To gain hands-on experience in the conduction of nuclear radiation measurements, as also in the execution and analysis of reactor physics experiments using the CROCUS reactor. |
| Content      | - Radiation detector systems, alpha and beta particles |
|              | - Radiation detector systems, gamma spectroscopy |
|              | - Introduction to neutron detectors (He-3, BF3) |
|              | - Slowing-down area (Fermi age) of Pu-Be neutrons in H2O |
|              | - Approach-to-critical experiments |
|              | - Buckling measurements |
|              | - Reactor power calibration |
|              | - Control rod calibration |
| Literature   | Distributed documents, recommended book chapters |
| Prerequisites / notice | Prerequisite for: Special Topics in Reactor Physics (2nd sem.) |

| 151-2043-00L | Radiation Biology, Protection and Applications (EPFL)                   | O    | 4    | 3G    | external organisers        |
|              | No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL. |
| Abstract     | An introductory course in the basic concepts of radiation detection and interactions and energy deposition by ionizing radiation in matter, radioisotope production and its applications in medicine, industry and research. The course includes presentations, lecture notes, problem sets and seminars. |
By the end of the course, the student must be able to:

1. Explain the basic physics principles that underpin radiotherapy, e.g., types of radiation, atomic structure, etc.
2. Explain the interaction mechanisms of ionizing radiation at keV and MeV energies with matter.
3. Explain the principles of radiation dosimetry.
4. Explain the principles of therapeutic radiation physics including X-rays, electron beam physics, radioactive sources, use of unsealed sources and Brachytherapy.
5. Define quality assurance and quality control, in the context of radiotherapy and the legal requirements.
6. Explain the principles and practice of radiation protection, dose limits, screening and protection mechanisms.

By the end of the course, the student must be able to:

- Formulate the operating point of a hydraulic turbomachine
- Specify a type of hydraulic turbine
- Sketch the layout of a hydraulic turbomachine
- Select appropriately the dimensions of a hydraulic turbomachine

The goal of the course is to provide the physics and technology basis for controlled fusion research, from the main elements of plasma physics to the reactor concepts.

By the end of the course, the student must be able to:

- Design the main elements of a fusion reactor
- Identify the main physics challenges on the way to fusion
- Identify the main technological challenges of fusion

The goal of the course is to provide the physics and technology basis for controlled fusion research, from the main elements of plasma physics to the reactor concepts.

By the end of the course, the student must be able to:

- Describe how to use radiotherapy equipment both for tumour localisation, planning and treatment.
- Design the main elements of a fusion reactor
- Identify the main physics challenges on the way to fusion
- Identify the main technological challenges of fusion

The goal of the course is to provide the physics and technology basis for controlled fusion research, from the main elements of plasma physics to the reactor concepts.

By the end of the course, the student must be able to:

- Explain the basic physics principles that underpin radiotherapy, e.g., types of radiation, atomic structure, etc.
- Explain the interaction mechanisms of ionizing radiation at keV and MeV energies with matter.
- Explain the principles of radiation dosimetry.
- Explain the principles of therapeutic radiation physics including X-rays, electron beam physics, radioactive sources, use of unsealed sources and Brachytherapy.
- Describe how to use radiotherapy equipment both for tumour localisation, planning and treatment.
- Define quality assurance and quality control, in the context of radiotherapy and the legal requirements.
- Explain the principles and practice of radiation protection, dose limits, screening and protection mechanisms.
### Abstract
The course presents basic physics ideas underlying the workings of modern accelerators. We will examine key features and limitations of these machines as used in accelerator driven sciences like high energy physics, materials and life sciences.

### Objective
By the end of the course, the student must be able to:
- Design basic linear and non-linear charged particles optics
- Elaborate basic ideas of physics of accelerators
- Use a computer code for optics design
- Optimize accelerator design for a given application
- Estimate main beam parameters of a given accelerator

### Content
Overview, history and fundamentals
- Transverse particle dynamics (linear and nonlinear)
- Longitudinal particle dynamics
- Linear accelerators
- Circular accelerators
- Acceleration and RF-technology
- Beam diagnostics
- Accelerator magnets
- Injection and extraction systems
- Synchrotron radiation

### Literature
Recommended during the course
- Prérequis: Notion de relativité restreinte et d'électrodynamique

### Prerequisites / notice
- Required courses: Physics I and Physics II
- Important concepts to start the course: Conservation principles (energy, mass, momentum)

### 151-2041-00L
**Introduction to Medical Radiation Physics (EPFL)**

**W** 4 credits  3G  external organisers

**Abstract**
This course covers the physical principles underlying medical imaging using ionizing radiation (radiography, fluoroscopy, CT, SPECT, PET).

**Objective**
The focus is not only on risk and dose to the patient and staff, but also on an objective description of the image quality.

**Content**
- Physics of radiography: X-ray production, Radiation-patient interaction, Image detection and display
- Image quality: Wagner's taxonomy, MTF, NPS, contrast, SNR, DQE, NEQ, CNR
- Dose to the patient: External irradiation, Internal contamination, compartmental models
- Physics of computer tomography (CT)
- Risk and radiation: Rational risk and state of our knowledge, Psychological aspects, Ethics and communication
- Physics of single-photon emission computed tomography (SPECT)
- Physics of mammography
- Receiver operating characteristics (ROC) and hypothesis testing: Link between medical diagnostic and statistical hypothesis testing, Sensitivity, specificity, prevalence, predictive values
- Physics of radioscopy
- Model observers in medical imaging: Human visual characteristics and their quantification, Bayesian cost and Ideal model observer, Anthropomorphic model observers, Detection experiments (rating, M-AFC, yes-no)
- Physics of positron emission tomography (PET)
- Physics of resonance magnetic imaging

### 151-2049-00L
**Energy Conversion and Renewable Energy (EPFL)**

**W** 4 credits  4G  external organisers

**Abstract**
The goal of the lecture is to present the principles of the energy conversion for conventional and renewable energy resources and to explain the most important parameters that define the energy conversion efficiency, resources implications and economics of the energy conversion technologies.

**Objective**
By the end of the course, the student must be able to:
- Explain the efficiency and the main emission sources of energy conversion processes
- Quantify the efficiency and the main emission sources of energy conversion processes
- Model energy conversion systems and industrial processes
- Draw the energy balances of an energy conversion system
- Elaborate energy conversion scenarios
- Describe the principles and limitations of the main energy conversion technologies
- Compare energy conversion systems

**Content**
- Overview of energy stakes
- Thermodynamic principles relevant for energy conversion systems, review of thermodynamic power cycles, heat pumps and refrigeration cycles, co-generation
- Carbon capture and sequestration
- Renewable energy vectors, their physical principles and essential equations: Solar (photovoltaics and thermal - collectors/concentrators), geothermal, biomass (a.o. gasification, biogases, liquid biofuels), hydro, wind
- Fuel cells and hydrogen as energy vector
- Storage of energy: Batteries, compressed air, pumped hydro, thermal storage
- Integrated urban systems

**Lecture notes**
Slides, videos and other documents are available on moodle (http://moodle.epfl.ch)

**Prerequisites / notice**
Required courses: Physics I and Physics II

### 151-2051-00L
**Radiation Detection (EPFL)**

**W** 3 credits  3G  external organisers

**Abstract**
The course presents basic physics ideas underlying the workings of modern accelerators. We will examine key features and limitations of these machines as used in accelerator driven sciences like high energy physics, materials and life sciences.

**Objective**
By the end of the course, the student must be able to:
- Design basic linear and non-linear charged particles optics
- Elaborate basic ideas of physics of accelerators
- Use a computer code for optics design
- Optimize accelerator design for a given application
- Estimate main beam parameters of a given accelerator

**Content**
Overview, history and fundamentals
- Transverse particle dynamics (linear and nonlinear)
- Longitudinal particle dynamics
- Linear accelerators
- Circular accelerators
- Acceleration and RF-technology
- Beam diagnostics
- Accelerator magnets
- Injection and extraction systems
- Synchrotron radiation

**Literature**
Recommended during the course
- Prérequis: Notion de relativité restreinte et d'électrodynamique
The course presents the detection of ionizing radiation in the keV and MeV energy ranges. It introduces the physical processes of radiation/matter interaction. It covers the several steps of detection, and the detectors, instrumentations and measurements methods commonly used in the nuclear field.

By the end of the course, the student must be able to:
- Explain interaction processes of ionising radiation and matter
- Describe the production of a detection signal and its processing
- Explain the operation of all types of commonly used detectors
- Assess / Evaluate the detection system and method required for a specific measurement

Interaction of radiation with matter at low energies: X-rays/gammams, charged particles and neutrons up to MeV range, ionisation, nuclear cross-sections.
- Characteristics and types of detectors: gas detectors, semiconductor detectors, scintillators and optical fibers, fission chambers, meshed and pixel detectors
- Signal processing and analysis: types of electronics, signal collection and amplification, particle discrimination, spatial and time resolution
- Nuclear instrumentation and measurements: principle of measurements, spectrometry, common detection instrumentations, applications in nuclear engineering and R&D.

Objective

By the end of the course, the student must be able to:
- Integrate the notions of critical reading of articles
- Assess / Evaluate scientific articles, their quality and defaults
- Interpret knowledge of several specific experimental methods

Noise and interference: Their origins, their influence on experimental results, methods for noise and interference reduction
- Scanning probe microscopy (SPM): Principles of operation of the scanning tunneling microscope and atomic force microscope, Advanced scanning microscopy techniques, applications
- Optical spectroscopys: The elements of a modern spectroscopy system; different methods of spectral dispersion and their advantages, optical detectors. Related methods: raman spectroscopy, cathodoluminescence.
- Electron microscopy: Transmission and scanning microscopes, their principles of operation, observation techniques, uses ...
- Structural characterization: RX, electron diffraction, ...

Abstract

By the end of the course, the student must be able to:
- Elaborate morphological filters
- Construct image-processing software
- Analyze multidimensional linear shift-invariant systems
- Design digital filters in 2-D
- Formalize convolution and optical systems
- Optimize 2-D sampling to avoid aliasing
- Select appropriately Hilbert spaces and inner-products
- Exploit the multidimensional Fourier transform

Objective

By the end of the course, the student must be able to:
- Assess / Evaluate the detection system and method required for a specific measurement
- Explain the operation of all types of commonly used detectors
- Discuss / Evaluate scientific articles, their quality and defaults
- Interpret knowledge of several specific experimental methods

Behavior at very high energies: Photons and particles, energetic particle transport, direct and indirect particle production, properties of hadron showers, hadron transport in the atmosphere, properties of hadron showers, properties of photon showers, properties of photon transport. Introduction to image analysis and computer vision. Segmentation, edge detection, objet detection, image comparison.

Objective

By the end of the course, the student must be able to:
- Master the concepts of thermodynamic efficiency, E6
- Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance, E22
- Analyse the energy and exergy efficiency of industrial energy systems, E23
- Design model and optimize energy conversion systems and industrial processes, E24
- Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance, E20
- Explain and apply the concepts of thermodynamic efficiency, E6
- Analyse the energy and exergy efficiency of industrial energy systems, E21
- Design model and optimize energy conversion systems and industrial processes, E22

Abstract

By the end of the course, the student must be able to:
- Explain interaction processes of ionising radiation and matter
- Describe the production of a detection signal and its processing
- Explain the operation of all types of commonly used detectors
- Assess / Evaluate the detection system and method required for a specific measurement

Interaction of radiation with matter at low energies: X-rays/gammams, charged particles and neutrons up to MeV range, ionisation, nuclear cross-sections.
- Characteristics and types of detectors: gas detectors, semiconductor detectors, scintillators and optical fibers, fission chambers, meshed and pixel detectors
- Signal processing and analysis: types of electronics, signal collection and amplification, particle discrimination, spatial and time resolution
- Nuclear instrumentation and measurements: principle of measurements, spectrometry, common detection instrumentations, applications in nuclear engineering and R&D.

Objective

By the end of the course, the student must be able to:
- Integrate the notions of critical reading of articles
- Assess / Evaluate scientific articles, their quality and defaults
- Interpret knowledge of several specific experimental methods

Noise and interference: Their origins, their influence on experimental results, methods for noise and interference reduction
- Scanning probe microscopy (SPM): Principles of operation of the scanning tunneling microscope and atomic force microscope, Advanced scanning microscopy techniques, applications
- Optical spectroscopys: The elements of a modern spectroscopy system; different methods of spectral dispersion and their advantages, optical detectors. Related methods: raman spectroscopy, cathodoluminescence.
- Electron microscopy: Transmission and scanning microscopes, their principles of operation, observation techniques, uses ...
- Structural characterization: RX, electron diffraction, ...

Abstract

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- Analyze multidimensional linear shift-invariant systems
- Design digital filters in 2-D
- Formalize convolution and optical systems
- Optimize 2-D sampling to avoid aliasing
- Select appropriately Hilbert spaces and inner-products
- Exploit the multidimensional Fourier transform
151-2061-00L  Nuclear Interaction : from Reactors to Stars (EPFL)  W  4 credits  4G  external organisers

Abstract: This course will present an overview of the nuclear interactions for neutrons on nuclei below a few hundreds of MeV. The aspect of so-called "nuclear data" will be presented from the perspective of experiments, compilation, calculation, evaluation, processing and applications.

Objective: By the end of the course, the student must be able to: Use applications codes.

Content:
- Nuclear data needs: It is important to understand if, and where, nuclear data are needed, why, which accuracy is required from the applications or industries. Such needs concerns a large range of applications: energy, medical, waste and astrophysics. Each of these fields requires different knowledge on nuclear interactions with, either with neutrons, or protons, or both.
- Theoretical background: Many of the needs are covered by experimental knowledge, but not all. Some reactions cannot be easily measured, or are simply out of range with current technologies (for instance for with short-lived isotopes). What can we do in this case? Part of the answer relies on theoretical understanding and the prediction power of current models (with their shortcoming). We will then explore (not in details) some of the important models, their range of applications, and what to do when nothing is known.
- Measurement facilities: The current knowledge of nuclear interactions, cross sections and uncertainties is based on measurements. In many instances, measurements are necessary due to the lack of prediction power for models. We will see the existing facilities, their advantages and drawback. We will also visit the installation worldwide, with a view on the future needs.
- Evaluation: Once quantities have been measured or calculated, they need to be presented to potential users. This step is called "evaluation". The outcome of the process is "what the users will see". It covers compiling measurements, combining them with theoretical predictions, formatting, and processing in forms that users need. We will go through these steps, and you will globally understand the importance of these steps.
- Applications: finally, we will see how these nuclear data are used. What are the applications, what are the needs, and how users can propose feedback to influence new measurements, or new calculations.

151-2063-00L  Numerics for Fluids, Structures and Electromagnetics (EPFL)  W  5 credits  4G  external organisers

Abstract: The aim of the course is to give a theoretical and practical knowledge of the finite element method for saddle point problems, such as the ones of fluid dynamics, elasticity and electromagnetic problems.

Objective: By the end of the course, the student must be able to:
- Identify features of a PDE relevant for the selection and performance of a numerical algorithm.
- Assess / Evaluate numerical methods in light of the theoretical results.
- Implement numerical methods for saddle point problems
- Choose an appropriate method to solve a given differential problem
- Prove convergence of a discretisation scheme

Content:
I Collisional and relaxation phenomena
- Inelastic collisions: ionization and recombination, degree of ionization
- Elastic collisions: Coulomb collisions
- Isotopisation and thermalisation
- Plasma resistivity and the runaway regime
II Transport in plasmas
- Random walk and diffusion
- Ambipolar and cross-field diffusion
- Energy and particle confinement
III Waves in cold magnetized plasma
- Dielectric tensor
- Resonances and cut-offs
- Parallel and perpendicular propagation
IV Wave-particle interaction and kinetic description of waves in hot un-magnetized plasmas
- The Vlasov-Maxwell model
- Resonant wave-particle interaction and Landau damping
- Stability criteria and streaming instabilities
- Langmuir and ion-acoustic waves and instabilities
V Waves in hot magnetized plasmas
- VI Examples of nonlinear effects

151-2067-00L  Plasma I (EPFL)  W  6 credits  5G  external organisers

Abstract: Following an introduction of the main plasma properties, the fundamental concepts of the fluid and kinetic theory of plasmas are introduced. Applications concerning laboratory, space, and astrophysical plasmas are discussed throughout the course.

Objective: By the end of the course, the student must be able to:
- Manipulate the fundamental elements of the plasma fluid and kinetic theory

Content:
I Collisional and relaxation phenomena
- Inelastic collisions: ionization and recombination, degree of ionization
- Elastic collisions: Coulomb collisions
- Isotopisation and thermalisation
- Plasma resistivity and the runaway regime
II Transport in plasmas
- Random walk and diffusion
- Ambipolar and cross-field diffusion
- Energy and particle confinement
III Waves in cold magnetized plasma
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- Resonant wave-particle interaction and Landau damping
- Stability criteria and streaming instabilities
- Langmuir and ion-acoustic waves and instabilities
V Waves in hot magnetized plasmas
- VI Examples of nonlinear effects

151-2069-00L  Neutron and X-ray Scattering of Quantum Materials (EPFL)  W  4 credits  4G  external organisers

Abstract: Neutron and X-ray scattering are some of the most powerful and versatile experimental methods to study the structure and dynamics of materials on the atomic scale. This course covers basic theory, instrumentation and scientific applications of these experimental methods.
To acquire hands-on experience with the running of large computer codes in relation to the static analysis of nuclear reactor cores and the multi-physics simulation of nuclear power plant (NPP) dynamic behaviour.

**Objective**
- Plan, predict and interpret neutron scattering experiments
- Read and evaluate articles containing neutron scattering results

**Content**
Neutron scattering is one of the most powerful and versatile experimental methods to study the structure and dynamics of materials on the nanometer scale. Its application spans from crystalline matter to bio-materials and engineering, including fields like magnetism and superconductivity. Similar to the vast possibilities with X-rays at synchrotron facilities, neutron scattering is a so-called large scale facility technique with neutron facilities among other at PSI in Switzerland, ILL in Grenoble and a new joint European Spallation Source under construction in Sweden.

The course provides an introduction to the versatile experimental techniques of neutron scattering and covers the following aspects:

1. Theory of the neutron scattering cross section
2. Neutron sources and neutron instrumentation
3. Neutron imaging, neutron reflectivity and neutron small angle scattering
4. Neutron diffraction, crystal structures
5. Inelastic neutron scattering, phonons
6. Magnetic neutron scattering, magnetic structures
7. Inelastic magnetic neutron scattering, magnetic dynamics
8. Resonant Inelastic X-ray Scattering (RIXS) a complementary technique

The course contain lectures and exercise sessions. Exercise sessions will contain deriving relevant formulas, monte-carlo simulation of neutron scattering experiments, and discussion of representative scientific articles using neutron scattering. We use partially flip-class room format for interactive learning.

**Objectives and Literature**

- Read and evaluate articles containing neutron scattering results
- Develop understanding of fuel behavior under high burn-up conditions
- Acquire knowledge of advanced reactor and fuel technology
- Understand the role of neutron scattering in materials science

**Prerequisites**
- Solid State Physics 1 and 2
- Basic quantum mechanics

**Course Details**

- **Number**: 151-2039-00L
- **Title**: Beyond-Design-Basis Safety
- **Type**: O
- **ECTS**: 4 credits
- **Hours**: 3G
- **Lecturers**: A. Manera, T. Lind, D. Paladin

**Abstract**
Comprehensive knowledge is provided on the phenomena during a Beyond Design Bases Accident (BDBA) in a Nuclear Power Plants (NPP), on their modeling as well as on countermeasures taken against radioactive releases into the environment, both by Severe Accident Management Guidelines (SAMG), together with technical backfitting measures in existing plants and an extended design of new NPP.

**Objective**
- To acquire hands-on experience with the running of large computer codes in relation to the static analysis of nuclear reactor cores and the multi-physics simulation of nuclear power plant (NPP) dynamic behaviour.
- To understand the containment, countermeasures mitigating release of radioactive material into the environment (accident management measures, backfitting and extended design), assessment of timing and amounts of released radioactive material (source term).
Content
Physical basic understanding of severe accident phenomenology: loss of core cooling, core dryout, fuel heat-up, fuel rod cladding oxidation and hydrogen production, loss of core coolability, and fuel melting, melt relocation and melt accumulation in the lower plenum of the reactor pressure vessel (RPV), accident evolution at high and low reactor coolant system pressure, heat flux from the molten debris in the lower plenum and its distribution to the lower head, RPV failure and melt ejection, direct containment heating, melt corium and concrete interaction, in- and ex-vessel molten fuel coolant interaction (steam explosions), hydrogen distribution in the containment, hydrogen risk (deflagration, transition to detonation), pressure buildup and containment vulnerability, countermeasures mitigating/avoiding hydrogen deflagration, formation and deposition of radioactive aerosols, iodine behavior, plant ventilation-filteration systems, filtered venting to avoid containment failure and mitigate activity release into the environment, containment bypass scenarios, source term assessment, in-vessel and ex-vessel corium retention, behavior of fuel elements in the spent fuel pool during long-lasting station blackout, cladding oxidation in air, discussion of occurred severe accidents (Harrisburg, Chernobyl, Fukushima), internal and external emergency response. Probabilistic assessment and interfacing with severe accident phenomenology.

Lecture notes
Hand-outs will be distributed

Prerequisites / notice
Prerequisites: Recommended courses: 151-0156-00L Safety of Nuclear Power Plants plus either 151-0163-00L Nuclear Energy Conversion or 151-2015-00L Reactor Technology

151-2045-00L Decommissioning of Nuclear Power Plants
Students registered at ETH Zurich have to enroll to this course at ETH, EPFL students can enroll to this course directly at EPFL.

Abstract
Introduction to aspects of Nuclear Power Plant decommissioning including project planning and management, costs and financing, radiological characterization, dismantling/decontamination technologies, safety aspects and radioactive waste management considerations.

Objective
Aim of this course is to provide the students with an overview of the multidisciplinary issues that have to be addressed for the successful decommissioning of NPPs. Students will get exposed to principles of project management, operations management, cost estimations, radiological characterization, technologies relevant to the safe dismantling of NPPs and best-practice in the context of radioactive waste management.

Content
Legal framework, project management and operations methods and tools, cost estimation approaches and methods, nuclear calculations and on-site radiological characterization and inventorying, state-of-the-art technologies for decontamination and dismantling, safety considerations, state-of-the-art practice for radioactive waste treatment, packaging and transport, interface with radioactive waste management and disposal. The course will additionally include student visits to relevant nuclear sites in Switzerland and Germany.

Lecture notes
Slides will be handed out.

Literature

151-2005-00L Elective Project Nuclear Engineering
The subject of the Elective Project and the choice of the supervisor (ETH or EPFL professor) are to be approved in advance by the tutor.

Abstract
The elective project has the purpose to train the students in the solution of specific engineering problems related to nuclear technology. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Objective
The elective project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

Content
Basis assessment and interfacing with severe accident phenomenology.

227-0395-10L Biomedical Imaging
Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Abstract
Upon completion of the course students are able to:
- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications
- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Prerequisites / notice
Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and subject-specific competencies.

Industrial Internship

Abstract

The main objective of the minimum twelve-week internship is to expose Master’s students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Objective

The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Semester Project

Abstract

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Objective

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program.

Master’s Thesis

Abstract

Master’s programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by teh tutor and further elaborated with the student.

Objective

The thesis is aimed at enhancing the student’s capability to work independently toward the solution of a theoretical or applied problem.
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<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
535-0030-00L  Pharmaceutical Immunology II & Therapeutic Proteins  
Prerequisites: Either 535-0830-00L Pharmaceutical Immunology I or 551-0317-00L Immunology I must have been taken.

Abstract: In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

Objective: Students know and understand:
- basic mechanisms and regulation of the immune response
- the pathogenic mechanisms of the most important immune-mediated disorders
- the concepts of vaccination and cancer immunotherapy
- the most frequently used expression systems for the production of therapeutic proteins
- the use of protein engineering tools for modifying different features of therapeutic proteins
- the mechanism of action of selected therapeutic proteins and their application
- basic concepts in the GMP production of therapeutic proteins

Content: The course consists of two parts:
In the first part, students will complete their training in Pharmaceutical Immunology. This part particularly focuses on the pathogenic mechanisms of immune-mediated diseases, vaccination and cancer immunotherapy. Deepened knowledge of immunology will be relevant for understanding the mechanism of action of many therapeutic proteins, as well as for understanding one major concern related to the use of protein-based drugs, namely, immunogenicity.
The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

Lecture notes: Handouts to the lectures will be available for downloading under http://www.pharma.ethz.ch/scripts/index

Literature:
- Janeway's Immunobiology, by Kenneth Murphy (9th or 10th Edition)
- Lecture Handouts
- Paper References provided in the Scripts
- EMEA Dossier for Humira

835-0041-00L  Pharmacology and Toxicology III
Prerequisites: Either 535-0830-00L Pharmaceutical Immunology I or 551-0317-00L Immunology I

Abstract: The course is divided into three parts. The first part provides an overview of drugs used for the pharmacotherapy of infectious diseases, osteoporosis, autoimmune diseases and cancer. The second part gives an overview of the field of medical virology, and the third part is focused on pharmacogenomics of drug metabolism and basic concepts of toxicology.

Objective: The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases, osteoporosis, autoimmune diseases and cancer. The course also provides an overview of the fields of medical virology, toxicology, and pharmacogenomics with a special focus on the role of genetic polymorphisms in drug response and adverse effects.

Content: Topics include the pharmacology and pharmacotherapy of infectious diseases, osteoporosis, autoimmune diseases and cancer. Medical virology covers important viral infections and their pharmacotherapy with different classes of antiviral drugs. In the field of pharmacogenomics, the course is focused on examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development. Finally, basic concepts of toxicology are introduced.

Lecture notes: A script is provided for each lecture. The scripts define important and exam-relevant contents of the lectures. Scripts do not replace the lectures.

Literature:
Recommended reading:
The classic textbook in Pharmacology:
Goodman and Gilman’s The Pharmacological Basis of Therapeutics
Laurence Brunton, Bjorn C. Knollman.
14th edition (2022)
ISBN-10: 1264258070

or

Klaus Aktories, Veit Flockerzi, Ulrich Förstermann, Franz Hofmann.
Allgemeine und spezielle Pharmakologie und Toxikologie.
13th edition (2022)
Urban & Fischer (Elsevier)
This course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through:


**Concepts and Theories**

Introduction to the principles, methods and applications of pharmacoepidemiology and drug safety. Drug safety in the pharmaceutical industry and regulatory authorities, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.

**Objectives**

- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for clinical pharmacists in hospitals and office pharmacies.
- Perform independently a causality assessment of suspected adverse drug reactions in patients
- Study designs and biostatistics used for data evaluation of drug safety
- Setup of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals

**Content**

- Historical landmarks of drug safety
- Pharmacovigilance and causality assessment
- Drug safety in premarketing clinical trials
- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding
- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPs)
- Medication errors, clinical pharmacology / clinical pharmacy
- Clinical Decision Support Systems, Interventional Pharmacoepidemiology
- Pharmacoepidemiological databases, 'Big Data'
- Interactive discussion of many real-life examples for each topic

**Literature**

- Rothman: Introduction to Epidemiology
- Strom, Kimmel, Hennessy: Textbook of Pharmacoepidemiology
- Gigerenzer: Risk Savvy - How to Make Good Decisions

Reading material and scripts will be provided for each week.

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**535-0050-00L Pharmacopei'diology and Drug Safety**

**Objective**

Basic knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

**Content**

1. Introduction into industrial property (patents, trademarks, industrial designs);
2. Prosecution of patent applications (patentability);
3. Patent information (patent publications, databases, searches);
4. Exploitation and enforcement of patents (possibilities of exploitation, licenses, parallel imports, scope of protection, patent infringement);
5. Peculiarities in pharmaceutics and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication);
6. Social, political and ethical aspects (patents and prices for medicinal products, traditional knowledge and ethnomedicine, bioprospecting and biopiracy, human DNA inventions);
7. Trademarks, types of trademarks, grounds for refusal, peculiarities of pharma trademarks.

**Lecture notes**

A script is provided in electronic form during the lecture.

**Literature**

This introductory class provides an overview of the basic scientific writing techniques and a guideline to presenting scientific data, together with guided exercises and hands-on training. It is devised to accompany the research projects within the curriculum of the MSc in Pharmaceutical Sciences. Further readings will be listed in the lecture notes.

### Objective

- Understand the drug discovery process and can explain major approaches and relevant technical terms (for details see lecture notes).
- Understand and appreciate the content and timing of drug development process steps, development phases and decision criteria.
- Understand the concepts underlying drug product development through all the phases from preclinical and clinical development to regulatory submission, approval and market launch.
- Can differentiate between small molecule drug development and biological drug development.
- Understand the most important differences for drug development and approval between the EU and USA pharma markets with regard to legal and regulatory requirements.

### Content

Course unit comprises weekly lectures covering the early phases of target and drug discovery (535-0901-01 S "From A to Z in Drug Discovery and Development I") with group work in the area of Drug Development (511-0000-00 G). The latter course lasts 2 full days (Days 1 and 2) and comprises both lectures and group work: inter alia an introduction to the entire suite of drug product development processes in the pharmaceutical industry, covering preclinical research and development, clinical development, regulatory processes and market launch. R&D support processes such as project management, quality management, pharmacovigilance and pharmacoconomics will be covered as well as organizational and governance aspects of the pharmaceutical industry. In addition, important success factors for a later career in the pharmaceutical industry will be briefly discussed at the end of day 2 of the course.

### Prerequisites / notice

- This course provides the essential basic knowledge required for the industry-specific modules of the spring semester.
- Will be published on "mystudies" Safety concept: https://chab.ethz.ch/studium/bachelor1.html

### Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Cooperation and Teamwork</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

### Literature

- Further readings will be listed in the lecture notes.

### Notice

The ECTS are earned by mandatory tasks which require your personal presence in the lecture.
The main objectives of this course are:
- students develop their scientific reflection (Critical Thinking) and working skills by working independently on a relevant pharmaceutical topic
- students gain in-depth knowledge of the topic investigated
- students train their scientific writing and presentation skills
- students train their ability to plan a project and work in a team

This course provides the basic concepts of biopharmacy (ADMET, absorption, distribution, metabolism, excretion, toxicity of drugs) and fosters knowledge of the ADMET processes and the respective pharmacokinetic parameters.

The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences.

The course Drug Seminar takes place during the first 7 weeks of the 1. Master semester. It is a compulsory course of the MSc Pharmacy curriculum and an elective course in the MSc PharmSciences.

The course provides an introduction to the fundamental parameters and concepts, the participants will study independently and apply and consolidate their knowledge in tutorials.

This course provides the basic concepts of biopharmacy (ADMET, absorption, distribution, metabolism, excretion, toxicity of drugs) and pharmacokinetics. After an introduction to the fundamental techniques and concepts, the participants will study independently, apply and consolidate their knowledge in tutorials.

## Prerequisites / notice

Only for students of MSc Pharmacy and MSc Pharmaceutical Sciences.

## Competencies

### Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

### Method-specific Competencies

- Analytical Competencies
- Project Management

### Social Competencies

- Communication
- Cooperation and Teamwork

### Personal Competencies

- Adaptability and Flexibility
- Critical Thinking
- Self-direction and Self-management

## Literature


DOI: 10.1002/9783527645763

![Image](http://onlinelibrary.wiley.com/book/10.1002/9783527645763)

## Problem-solving

- Design of dosage regimens. In vitro assays to predict pharmacokinetic parameters.
- Interpretation of pharmacokinetic parameters.
- Analysis of drug plasma concentration-time curves.
- Prediction of pharmacokinetic parameters based on in vitro assays and physicochemical drug properties.
- Knowledge of the effects of physiological factors on the pharmacokinetic parameters and on drug plasma and tissue concentrations.
- Design of dosage regimens, based on pharmacokinetic parameters.
- Prediction of drug-drug interaction potentials based on in vitro assays and pharmacokinetic parameters.
- Introduction to biopharmacy (ADMET) and pharmacokinetics.
- Definition of the most important pharmacokinetic parameters and their calculation from plasma concentration-time curves.
- Introduction to compartment models, statistical models, physiological models.
- Pharmacokinetic profiling of drugs for therapy optimization and for the analysis of the interaction potential.
- Design of dosage regimens. In vitro assays to predict pharmacokinetic parameters.

## Lecture notes

Slides, see documents repository.

## Content

- Students gain knowledge in pharmaceutical analytics to fulfill regulatory requirements in pharmaceutical industry based on the pharmacopeia in force. Focus is set on method validation, equipment qualification, identification, purity testing and content determination of active pharmaceutical ingredients and excipients.
- Students train their scientific writing and presentation skills.
- Students develop their scientific reflection (Critical Thinking) and working skills by working independently on a relevant pharmaceutical topic.
- Students gain in-depth knowledge of the topic investigated.
- Students train their ability to plan a project and work in a team.

## Method-specific Competencies

- Analytical Competencies
- Project Management

## Social Competencies

- Communication
- Cooperation and Teamwork

## Personal Competencies

- Adaptability and Flexibility
- Critical Thinking
- Self-direction and Self-management

## Credit points restricted to students assigned by the Admission committee.
### Gene Technology (Crash Course)

**E-** 1 credit 1S  J. Scheuermann

**Abstract**
The course enables the student to understand and apply the general concepts of gene technology, including recombinant DNA technology and its application in genomics, transcriptomics and proteomics. Protein cloning, expression and modifications and bimolecular interactions will be discussed. The concept of display technology and its applications in the field of drug discovery will be presented.

**Objective**
The students remember and understand:
1. The tools of recombinant DNA technology
2. Next generation sequencing approaches and their relevance for -omics projects
3. Protein cloning, expression, modification/labelling and oligomerisation
4. Thermodynamic and kinetic affinity constants in bimolecular reactions
5. Basic structure of the antibody molecule
6. Concepts of antibody phage technology and antibody engineering
7. Construction of antibody-, peptide- or small molecule libraries and affinity-based selection methodologies

**Content**

1) **Genomics:** recombinant DNA technology methods to sequence genomes application to human biology Transcriptomics / Proteomics
2) **Proteins:** protein cloning and expression homo- and heterodimerization chemical modifications and radioactive labelling detection of bimolecular interactions affinity constant and experimental measurement kinetic association and dissociation constants
3) **Display technology:** the antibody molecule, CDRs, basics of antibody engineering antibody phage display and selection methodologies construction of antibody libraries other display technologies (peptide display, DNA-encoded chemical libraries)

**Lecture notes**
Slides and script used for the course and literature for reading and discussions will be made available online.

**Literature**

**Prerequisites / notice**
Admission to MSc in Pharmaceutical Sciences

### Drug Delivery and Drug Targeting

**W** 2 credits 1.5V  J.-C. Leroux

**Abstract**
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

**Objective**
The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

**Content**

- micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.
- The tools of recombinant DNA technology
- application to human biology
- Transcriptomics / Proteomics
- protein cloning and expression
- homo- and heterodimerization
- chemical modifications and radioactive labelling
- detection of bimolecular interactions
- affinity constant and experimental measurement
- kinetic association and dissociation constants
- the antibody molecule, CDRs, basics of antibody engineering
- antibody phage display and selection methodologies
- construction of antibody libraries
- other display technologies (peptide display, DNA-encoded chemical libraries)

**Lecture notes**
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

**Literature**


Further references will be provided in the course.

### Biotransformation of Drugs and Xenobiotics

**W** 1 credit 1V  S.-D. Krämer

**Abstract**

The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

**Objective**
The course enables the student to understand and apply the general concepts of gene technology, including recombinant DNA technology and its application in genomics, transcriptomics and proteomics. Protein cloning, expression and modifications and bimolecular interactions will be discussed. The concept of display technology and its applications in the field of drug discovery will be presented.

**Content**

1) **Genomics:** recombinant DNA technology methods to sequence genomes application to human biology Transcriptomics / Proteomics
2) **Proteins:** protein cloning and expression homo- and heterodimerization chemical modifications and radioactive labelling detection of bimolecular interactions affinity constant and experimental measurement kinetic association and dissociation constants
3) **Display technology:** the antibody molecule, CDRs, basics of antibody engineering antibody phage display and selection methodologies construction of antibody libraries other display technologies (peptide display, DNA-encoded chemical libraries)

**Lecture notes**
Slides and script used for the course and literature for reading and discussions will be made available online.

**Literature**

**Prerequisites / notice**
Admission to MSc in Pharmaceutical Sciences
Abstract
Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Objective
Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Content
Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics. Toxic reactions of metabolites. Factors which affect the biotransformation.

Lecture notes
Biotransformation of drugs and xenobiotics

Literature

Competencies
Subject-specific Competencies
Concepts and Theories
Conceptual Thinking

Method-specific Competencies
Analytical Competencies

Personal Competencies
Creative Thinking

535-0015-00L History of Pharmacy

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<tr>
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<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>fostered</td>
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</table>

535-0344-00L From Ethnopharmacy to Molecular Pharmacognosy

Abstract
Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Objective
Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Content

Lecture notes
Handouts will be provided.

Literature

Prerequisites / notice
Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.
Vitamins are essential organic compounds that cannot be synthesized by an organism and hence, they have to be acquired from the diet.

To develop a critical understanding of the relevance and limitations of the current approaches to explaining and anticipating drug effects.

To critically appraise the ethical, societal, economical and political expectations in the development of new drugs.

These are the topics of the present course. Using three particularly informative examples of drug failures, the problems encountered and the limitations of an extremely reductionist view of atherosclerosis and its prevention by drug therapy. It has also highlighted what high expectations we have in a safe and wide applicability of drugs and of their economical success.

In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed the limitations of an extremely reductionist view of atherosclerosis and it's prevention by drug therapy. It has also highlighted what high expectations we have in a safe and wide applicability of drugs and of their economical success. Torcetrapib is not a single case. In the last 10 years, on average one drug per year was withdrawn from the market due to lack of efficacy, unexpected side effects or toxicity. This clearly shows that the common investigations and the modern understanding of drug actions are often not sufficient to predict the effects a drug will have in large patient populations.

The aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products.
Contents

Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications. Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested. A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period.

The lecture ‘Vitamins in Health and Disease’ will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.

Lecture notes

Hand-outs will be distributed during the lecture (partly in English, partly in German).

Literature

- Handbuch Nährstoffe, Burgerstein, Trias Verlag ISBN 978-3-8304-6071-8

Prerequisites / notice

Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.

535-0360-00L Evidence Based Phytotherapy W 1 credit 1V K. Berger Büter, S. Nicolussi

Abstract

Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed.

Objective

Content and aim of the lecture:

Students should learn about the importance of rational (= evidence-based) pharmacotherapy with herbal extracts and know which factors influence the quality of such medicinal products. The following topics are covered:

- How are interesting development candidates identified. What are the strategies?
- What are the regulatory requirements (traditional use, well-established use, new herbal entities)?
- Determination of efficacy from (animal/human studies, biomarkers)
- Quality of clinical studies
- Pharmacokinetics of phytopharmaceuticals
- Safety (toxicity, adverse effects, interactions)
- Pharmaceutical quality
- Varietal purity (wild collections, cultivation)
- Influence of genetic variability on extract quality
- Ensuring consistent quality
- Which extraction methods?

The topics are explained and critically discussed using various phytopharmaceuticals as examples (see programme below).

Content

Lecture notes

Effective Zeiten 15.45 - 16.30; 16.45-17.30

Comptencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: fostered
- Decision-making: fostered

Personal Competencies

- Critical Thinking: fostered

535-0137-00L Clinical Chemistry II W 1 credit 1V M. Hersberger

Abstract

Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

Objective

Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interprete selected tests.

Content

- Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

Lecture notes

Documentation will be available before the lectures electronically.

Literature

- Jürgen Hallbach, Klinische Chemie und Hämatologie für den Einstieg, Thieme Verlag
- Harald Renz, Praktische Labordiagnostik, de Gruyter Verlag
- Walter Guder, Das Laborbuch für Klinik und Praxis, Elsevier Verlag
- Lothar Thomas, Labor und Diagnose, TH Books
- William Marshall, Clinical Chemistry, Mosby Ltd.
- Alan H.B. Wu, Tietz, Clinical Guide to Laboratory Tests, Saunders

Prerequisites / notice

Requirement: basic knowledge in clinical chemistry and laboratory diagnostics.

535-0022-00L Computer-Assisted Drug Design W 1 credit 1V S. Riniker, G. Landrum

Abstract

The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

Objective

The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

Content

The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).

Lecture notes

Script will be available.

Literature

Recommended textbooks:

The lecture is organized as a two-week block during the practical course "Computer-Assisted Drug Design" (535-0023-00 P), totalling 10 two-hour lectures. It provides an introduction to advanced drug design techniques and approaches emphasizing computer-assisted molecular design.

Objective
Participants will learn about computational algorithms and advanced experimental approaches to drug discovery and design, including selected actual topics and practical applications. The contents of the lecture will allow for a deeper understanding of modern computer-assisted drug design methods and how they are linked to experimental applications. The main focus is on computational medicinal chemistry, so that participants will be able to use relevant computer-based methods in own research projects.

Literature

Prerequisites / notice
The lecture is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P). Additional selected literature will be provided during the lecture.

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### Research Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>511-0003-00L</td>
<td>Practical Methods in Pharmaceutical Sciences</td>
<td>O</td>
<td>8</td>
<td>17A</td>
<td>Lecturers</td>
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</table>

Abstract
Practical Methods in Pharmaceutical Sciences familiarise students with scientific procedures and operational methodologies through supervised participation in current research work.

Objective
Students get acquainted with scientific working methods and deepen their knowledge in a particular research area.

Competencies
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: assessed
  - Project Management: assessed
- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Sensitivity to Diversity: fostered
- **Personal Competencies**
  - Adaptability and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

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### Electives II

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<th>Number</th>
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<td>W</td>
<td>15</td>
<td>39A</td>
<td>Lecturers</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 1969 of 2667
Abstract
Research project familiarises students with scientific procedures and operational methodologies through supervised participation in current research work. The research group is chosen by the student.

Objective
Students get acquainted with scientific working methods and deepen their knowledge in a particular research area.

Prerequisites / notice
Prerequisite: Practical Methods in Pharmaceutical Sciences passed

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

511-0005-00L Internship W 10 credits 31A Lecturers

Abstract
The internship takes place outside universities, the main locations being: pharmaceutical industry, consultancy, health and regulatory authorities and hospitals. Students experience the professional handling of questions in the field of pharmaceutical sciences through their own practical activities.

Objective
In an internship the students experience the professional handling of questions in the field of pharmaceutical sciences through their own practical activities and be able to implement the knowledge gained, by:
- analysing problems in their complexity and developing solutions in a conceptual way,
- experiencing the aspects of an everyday working environment,
- acquiring key skills,
- establishing contacts for prospective careers.

Content
Work experience outside of university, duration of at least 12 weeks.

An Internship agreement is set up between the student, the company and a member of the teaching staff of the Institute of Pharmaceutical Sciences.

At the end of the internship, the student draws up a formal report.

511-0006-00L Consolidation Work W 7 credits 14A Lecturers

Abstract
The Consolidation Work consists of a literature work and provides an opportunity for the students to deeply investigate and consolidate their knowledge in a scientific or technical field of relevance to pharmaceutical sciences / the pharmaceutical industry.

Objective
- students develop their scientific reflection (“Critical Thinking”) and independent working skills on a topic relevant to pharmaceutical sciences / the pharmaceutical industry
- students gain in-depth knowledge of the topic investigated
- students train their scientific writing skills

Content
The Consolidation Work consists of a literature work and provides an opportunity for the students to deeply investigate and consolidate their knowledge in a scientific or technical field of relevance to pharmaceutical sciences / the pharmaceutical industry. Students work alone on a topic of their choice over a time period of maximally 12 weeks and elaborate a written review article. Over this time, the student is loosely supervised by a lecturer of the Master Study Program.

Master's Thesis

Number Title Type ECTS Hours Lecturers
511-0002-00L Master's Thesis O 30 credits 40D Lecturers

Abstract
In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is usually carried out in a subject area of Pharmaceutical Sciences as chosen by the student.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed

Science in Perspective
see Science in Perspective: Language Courses ETH/UZH
Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

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<th>Number</th>
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<td>535-0421-AAL</td>
<td>Galenical Pharmacy I+II</td>
<td>E-</td>
<td>4 credits</td>
<td>7R</td>
<td>J.-C. Leroux</td>
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<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>Principles and technologies for the manufacturing of dosage forms and drug delivery systems. Knowledge of pharmaceutical excipients, materials, containers, liquid, solid and semi-solid dosage forms, their production, function, quality and application.</td>
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<td>Objective</td>
<td>Knowledge of the most important pharmaceutical excipients, materials, containers, liquid, solid and semi-solid dosage forms, of their production, function, quality, stability and application. Comprehension of the molecular interactions in solid state, solution and colloidal systems.</td>
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<td>Competencies</td>
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<td>Problem-solving</td>
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<td>Creative Thinking</td>
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<tr>
<td>535-0521-AAL</td>
<td>Pharmacology and Toxicology I+II</td>
<td>E-</td>
<td>5 credits</td>
<td>7R</td>
<td>U. Quitterer</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>This course is a condition for admission to the Pharmaceutical Sciences Master. By self-directed learning, students acquire knowledge about basic principles in pharmacology and toxicology, mechanisms of drug action and clinical uses of important classes of drugs.</td>
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<td>Objective</td>
<td>After the successful completion of this course, students have gained knowledge about basic principles in pharmacology and toxicology, mechanisms of drug action and clinical uses of important classes of drugs.</td>
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<td></td>
<td>Content</td>
<td>Contents of this course are defined by the textbook &quot;Basic and Clinical Pharmacology&quot; by Bertram Katzung. The following sections are exam-relevant.</td>
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<td></td>
<td>Lecture notes</td>
<td>Course contents are defined by the textbook &quot;Basic and Clinical Pharmacology&quot; by Bertram Katzung and Anthony Trevor. Exam-relevant sections of this book are listed above in the contents section.</td>
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<td>376-0172-AAL</td>
<td>Anatomy I+II</td>
<td>E-</td>
<td>5 credits</td>
<td>11R</td>
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Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction into the histology and anatomy of the human body, including the musculoskeletal, cardio-respiratory, digestive, endocrine, urinary, reproductive systems, as well as the nervous system and sensory organs.

Objective
Students acquire basic knowledge of the micro- and macro structure of the organ systems in the human body. They understand basic concepts of the relationship between structure and function, and - based on examples - of the relationship between structural changes and disease.

376-0173-AAL Physiology I+II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Principles of human physiology and clinical pathophysiology.

Objective
Understand the basic principles of human physiology and mechanisms of related clinical pathophysiology.

406-0603-AAL Stochastics (Probability and Statistics)
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 4: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under:

  From within the ETH, this book is freely available online under:
  http://www.springerlink.com/content/m17578/

Competencies

Pharmaceutical Sciences Master - Key for Type

| W+ | Eligible for credits and recommended |
| W  | Eligible for credits                |
| E- | Recommended, not eligible for credits |

Key for Hours

| V  | lecture |
| G  | lecture with exercise |
| U  | exercise    |
| S  | seminar    |
| K  | colloquium |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

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Pharmaceutical Sciences Bachelor

First Year Compulsory Subjects

First Year Examinations

First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-1001-01L</td>
<td>General Chemistry (for Biol./Pharm.Sc.)</td>
<td>O</td>
<td>4 credits</td>
<td>4V+2U</td>
<td>J. Cvengros</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetiks, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.</td>
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</tr>
<tr>
<td><strong>Cometencies</strong></td>
<td>Subject-specific Competencies Concepts and Theories assessed</td>
<td></td>
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<tr>
<td></td>
<td>Method-specific Competencies Analytical Competencies assessed</td>
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<td>Decision-making assessed</td>
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<td></td>
<td>Problem-solving assessed</td>
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<td></td>
<td>Social Competencies Communication fostered</td>
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<td></td>
<td>Personal Competencies Adaptability and Flexibility fostered</td>
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<tr>
<td></td>
<td>Creative Thinking assessed</td>
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<tr>
<td></td>
<td>Critical Thinking assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics fostered</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection fostered</td>
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<tr>
<td></td>
<td>Self-direction and Self-management fostered</td>
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</tr>
</tbody>
</table>

| 529-1011-00L | Organic Chemistry I (for Biol./Pharm.Sc./HST) | O    | 4 credits | 4G | C. Thilgen |
| **Abstract** | Fundamentals of Organic Chemistry: molecular structure. Bonding and functional groups; nomenclature; resonance and aromaticity; stereochemistry; conformation; bond strength; organic acids and bases; basic reaction thermodynamics and kinetics; reactive intermediates: carbanions, carbenium ions and radicals. |
| **Objective** | Understanding the basic concepts and definitions of organic chemistry. Knowledge of the functional groups and classes of compounds that are important in biological systems. Foundations for the understanding of the relationship between structure and reactivity. |
| **Lecture notes** | Lecture notes are available (pdf file). Exercises, answer keys and other handouts can be downloaded from the Moodle course "Organic Chemistry I" of the current semester (https://moodle-app2.let.ethz.ch). |
| | • Organic Chemistry: From Molecules to the Biochemistry of Cells | 6 credits | 5G | J. Vorholt-Zambelli, N. Ban, R. Glockshuber, K. Locher, J. Piel |
| **Abstract** | The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts. |
| **Objective** | Introduction to biochemistry, molecular biology and evolutionary principles |
The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that operate within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biology are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

Lecture notes
The newly conceived lecture is supported by scripts.

Literature

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Critical Thinking
- Self-awareness and Self-reflection

First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
First identification with Pharmaceutical Sciences; motivation for profiling in the Natural Sciences, which are focused on within the first two years as a preparation for the specialized studies; sensitization for the duties and the responsibilities of a person with a federal diploma in Pharmacy; information about job opportunities.

Objective
First identification with Pharmaceutical Sciences; motivation for profiling in the Natural Sciences as a preparation for the specialized studies; sensitization for the duties and the responsibilities of a person with a federal diploma in Pharmacy; information about job opportunities.

Content
Introduction to Pharmaceutical Sciences by selected milestones of research and development. Overview on research activities at the Institute of Pharmaceutical Sciences that is focussed on drug delivery and development (from concepts to prototypes). Sensitization for communication skills and information management. Demonstration of job opportunities in community pharmacies, in the hospital, in industry, and in the public sector by experts in the different fields.

Lecture notes
Handouts for individual lectures.

Prerequisites / notice
Interactive teaching

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0291-00L</td>
<td>Mathematics I</td>
<td>O</td>
<td>6 credits</td>
<td>4V+2U</td>
<td>E. W. Farkas</td>
</tr>
</tbody>
</table>

Abstract
Mathematics I/II is an introduction to one- and multidimensional calculus and linear algebra emphasizing on applications.

Objective
Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences. Students can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems.
## Eindimensionale diskrete Entwicklungen ##
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsraten
- Folgen und Grenzwerte

## Funktionen in einer Variablen ##
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

## Differenzialrechnung (I) ##
- Veränderungsrate/-geschwindigkeit
- Differentialquotient und Ableitungsfunktion
- Anwendungen der Ableitungsfunktion

## Integralrechnung (I) ##
- Stammfunktionen
- Integrationstechniken

## Gewöhnliche Differentialgleichungen (I) ##
- Qualitative Beschreibung an Beispielen:
  - Beschränkt, Logistisch, Gompertz
  - Stationäre Lösungen
  - Lineare DGL 1. Ordnung
  - Trennung der Variablen

## Lineare Algebra ##
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

Lecture notes
In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem Vademecum zusammen.

Dabei gilt:
* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

Literature
Siehe auch Lernmaterial > Literatur

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände:
Einführung in die Analysis, Einführung in die Lineare Algebra; Haupt-Verlag Bern, UTB.

**H. H. Storrer**
Einführung in die mathematische Behandlung der Naturwissenschaften I; Birkhäuser.
Via ETHZ-Bibliothek:
https://link.springer.com/book/10.1007/978-3-0348-8598-0

**Ch. Blatter**
Lineare Algebra; VDF und als Skript in der PolyBox

**A. Caspar, N. Hungerbühler**
Mathematische Modellierung in den Life Sciences, Springer.
Via ETH-Bibliothek:

Prerequisites / notice

+ Die Übungsaufgaben (Handaufgaben, Khan-Aufgaben, Multiple-Choice) sind ein wichtiger Bestandteil der Lehrveranstaltung.
+ Es wird erwartet, dass Sie mindestens 9 von 13 der wöchentlichen Serien bearbeiten und zur Korrektur einreichen.
+ Der Prüfungsstoff ist eine Auswahl von Themen aus Vorlesung und Übungen. Für eine erfolgreiche Prüfung ist die konzentrierte Bearbeitung der Aufgaben unerlässlich.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
</tr>
</tbody>
</table>

402-0073-00L  Physics I  O 3 credits  2V+2U  T. M. Ihn

Abstract
Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics and elements of quantum mechanics
Objective
Students know and understand the basic ideas of the scientific description of nature. They understand the fundamental concepts and laws of mechanics and they are able to apply them in practical problems. They know the concepts of quantization and quantum numbers.

Content
1. Description of Motion
2. The laws of Newton
3. Work and energy
4. Collision problems
5. Wave properties of particles
6. The atomic structure of matter

Lecture notes
T. Ihn: Physics for Students in Biology and Pharmaceutica Sciences (unpublished lecture notes)

Literature
The lecture contains elements of:
Feynman, Leighton, Sands, "The Feynman Lectures on Physics", Volume I (http://www.feynmanlectures.caltech.edu/)

Competencies
Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Problem-solving

Method-specific Competencies
Cooperation and Teamwork
Sensitivity to Diversity

Social Competencies
Analytical Competencies

Analytical Competencies
Decision-making

Problem-solving

Critical Thinking

Sensitivity to Diversity

Self-awareness and Self-reflection

Self-direction and Self-management

Personal Competencies

Decision-making

Problem-solving

Self-awareness and Self-reflection

Self-direction and Self-management

Additional First Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>535-1001-00L</td>
<td>Laboratory Course General Chemistry (for Biology and Pharmacy)</td>
<td>O</td>
<td>6</td>
<td>8P</td>
<td>S. Gruber, J. Hall</td>
</tr>
</tbody>
</table>

Register in myStudies as early as possible, because the fire protection courses take place separately before the internship starts.

Abstract
Introduction to the practical work in a chemistry laboratory. The most important manipulations and techniques are treated, as well as the most fundamental chemical reaction types.

Objective
- Knowledge of the basic chemical laboratory methods
- Basic knowledge of the scientific approach in experimenting
- Observation and interpretation of chemical processes
- Keeping of a reliable laboratory journal

Content
- Simple chemical working techniques/methods
- Separation techniques
- Physical measurements: mass, volume, pH
- Ionic solids (salts)
- Acid/base chemistry, buffers
- Redox reactions
- Metal complexes
- Titration methods and quantitative spectrometry
- Introduction to qualitative analysis

Lecture notes
Course manual in German (is handed out to the students at the begin of the lessons)
Language: German. English upon request

Literature

is a suitable textbook.

Prerequisites / notice
This practical course causes costs for materials and chemicals. The costs are charged to the students at the end of semester.

By enrolling in this lab course, students confirm that they will thoroughly study and follow all safety information and instructions and that they have an accident insurance valid for Switzerland for the entire duration of the semester.

Competencies
Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Problem-solving

Method-specific Competencies
Cooperation and Teamwork
Sensitivity to Diversity

Social Competencies
Analytical Competencies

Analytical Competencies
Decision-making

Problem-solving

Critical Thinking

Sensitivity to Diversity

Self-awareness and Self-reflection

Self-direction and Self-management

Personal Competencies

Decision-making

Problem-solving

Self-awareness and Self-reflection

Self-direction and Self-management

Second Year Courses

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0852-00L</td>
<td>Foundations of Computer Science</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Dahinden, L. E. Fässler</td>
</tr>
</tbody>
</table>

This course provides selected computer science concepts for interdisciplinary projects.

The following topics are covered: introduction to programming, sequence analysis, modeling and simulations, introduction matrices, managing data with with relational databases.
Students learn to

- encode a problem into a program, test the program, and correct errors.
- understand and improve existing code.
- deal with the complexity of real data.
- store data in a suitable data structure.
- query databases and understand and evaluate the corresponding database model.
- implement models from the natural sciences as a simulation.
- run random experiments and interpret the results.
- explain and apply standard algorithms and evaluate their efficiency.

### Content

1. Variables, data types
2. Control structures, logic
3. Sequential data types, search- and sort algorithms, sequence analysis
4. Functions, modules, simulation and animation
5. Manage data with a relational database
6. Matrices, random experiments, cellular automata

### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork

**Personal Competencies**
- Adaptability and Flexibility
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Literature

- Alberts et al. 'Molecular Biology of the Cell' 6th edition
- Campbell "Biology", 11th Edition

### Prerequisites / notice

This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork

**Personal Competencies**
- Adaptability and Flexibility
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Prerequisites / notice

- Some lectures are held in English.
- All materials for the lecture are available at www.gdi.ethz.ch
- The lecture introduces the structural and functional specialization in fungi, plants and animals, including humans. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi, plants, animals and humans have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, human anatomy and physiology, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development.

### Literature

- Alberts et al. 'Molecular Biology of the Cell' 6th edition
- Campbell "Biology", 11th Edition

### Prerequisites / notice

- Some lectures are held in English.
Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography)

Subject-specific Competencies

Analytical Competencies

12P

Wird im Kurs bekannt gegeben.

The slides of the lectures will be provided.

Pharmaceutical Analytics I

O 5 credits 4V W. Langhans, M. Willecke, to be announced

Abstract

This course provides the basic concepts of pharmaceutical analytics in the context of pharmacopeial regulation by Ph. Eur and Ph. Helv.

Objective

Summarize the structure of the Ph. Eur.
Summarize the most important pharmacopoeias and their commonalities and differences (USP, JP, Ph.Eur., Ph. Helv.)
Discuss the structure of a monograph
Explain qualification of instruments and validation of methods
Explain and compare most important analytical techniques for pharmacies and pharmaceutical industry

Content

Knowledge in pharmaceutical analytics to fulfill regulatory requirements in pharmaceutical industry based on the pharmacopoeia in force.
Focus is set on method validation, equipment qualification, identification of functional groups and content determination of active pharmaceutical ingredients and excipients.

Lecture notes

Online-Material wird im Laufe des Kurses zur Verfügung gestellt.

Literature

Wird im Kurs bekannt gegeben.

Competencies

Subject-specific Competencies

Methods-specific Competencies

535-0225-00L Pharmaceutical Analytics II

O 3 credits 3G C. Steuer

Abstract

This course provides the basic concepts of pharmaceutical analytics in the context of pharmacopeial regulation by Ph. Eur and Ph. Helv.

Objective

Summarize the most important pharmacopoeias and their commonalities and differences (USP, JP, Ph.Eur., Ph. Helv.)
Discuss the structure of a monograph
Explain qualification of instruments and validation of methods

Content

Knowledge in pharmaceutical analytics to fulfill regulatory requirements in pharmaceutical industry based on the pharmacopoeia in force.
Focus is set on method validation, equipment qualification, identification of functional groups and content determination of active pharmaceutical ingredients and excipients.

Lecture notes

The slides of the lectures will be provided.

Literature

Instrumentelle Analytik; G. Rücker, M. Neugebauer, G. G. Willems; Deutscher Apotheker Verlag, Stuttgart
Arzneistoffanalyse; H. J. Roth, K. Eger, R. Troschütz; Deutscher Apotheker Verlag, Stuttgart
Introduction to Pharmaceutical Chemical Analysis; S. H. Hansen, S. Pedersen-Bjergaard, K. Rasmussen; Wiley & Sons

Prerequisites / notice

Requirements for the practical course Pharmaceutical Analytics:

Competencies

Subject-specific Competencies

Methods-specific Competencies

529-0229-00L Practical Course Organic Chemistry (for Students of Biology and Pharmaceutical Sciences)

O 8 credits 12P C. Thilgen

Latest online enrolment is 10 days before the beginning of the semester.
Students who did not pass the first-year examinations need the lecturers’ written permission to take this course.

Abstract

Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography)
Synthetic part (main part): at least 8 synthetic steps (one- or two-step syntheses).

Objective

Learn the basic techniques for the preparation and purification of organic compounds.
Learn to take accurate notes of the experiments and to write reports.
Deepen the understanding of reaction mechanisms.
Content
Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography).

Synthetic part (main part): at least 8 synthesis steps (one- to two-step preparations) from the following classes of reactions: 1. nucleophilic substitution at C(sp3), 2. elimination or electrophilic addition to a C=C bond, 3. electrophilic aromatic substitution, 4. reduction of an aldehyde/ketone, 5. Grignard reaction, 6. heterocyclization with imine/enamine formation, 7. synthesis of a carboxylic acid derivative by acyl group transfer, 8. aldol, Claisen, Mannich, Michael reaction or Robinson anellation.

Introduction to database searches (Reaxys, SciFinder).

Lecture notes
Written documents are distributed via Moodle course.

Literature
1) P. Wörfel, M. Bitzer, U. Claus, H. Helber, M. Hübel, B. Vollenweider, Laborpraxis (Bd. 1: Einführung, allgemeine Methoden; Bd. 2: Messmethoden; Bd. 3: Trennungsmethoden; Bd. 4: Analytische Methoden); Birkhäuser Verlag; Basel; 1990.

Prerequisites / notice
The basic reactions of Organic Chemistry and their mechanisms should be known and the corresponding exam have been passed (cf. course 529-1012-00L Organic Chemistry II for Students of Biology, Pharmaceutical Sciences, and Health Sci. and Tech.).

The prerequisite for participation is passing the ETH security exam.

By enrolling in this lab course, students confirm that they have thoroughly studied all safety information and will follow all instructions.

Competencies

Subject-specific Competencies
- Concepts and Theories: fostered
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: fostered
- Media and Digital Technologies: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Third Year Courses
Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0230-00L</td>
<td>Medicinal Chemistry I</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>J. Hall</td>
</tr>
</tbody>
</table>

Abstract
The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biological rules underlying ligand-target interactions will be discussed and illustrated with examples.

Objective
Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

Content
Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions.

Lecture notes

Prerequisites / notice
Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.

Attendance of Medicinal Chemistry II in the spring semester.

For Pharmacy and non-Pharmacy students, Medicinal Chemistry I and II are examined in a SINGLE examination (Jahresprüfung).

Number | Title                        | Type | ECTS | Hours | Lecturers   |
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>535-0421-00L</td>
<td>Galenical Pharmacy I</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>J.-C. Leroux, E. Giger</td>
</tr>
</tbody>
</table>

Abstract
Principles and technologies for the manufacturing of dosage forms and drug delivery systems. Knowledge of pharm. excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality and application. Comprehension of molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in dosage forms.

Objective
Knowledge of the most important pharmaceutical excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality, stability and application. Comprehension of the molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in dosage forms.

Content
Introduction and overview of important fundamentals, principles and technologies for the development and manufacturing of dosage forms and drug delivery systems. Overview of the most important pharmaceutical excipients and polymers, their structure, properties and processing; importance of materials properties for containers. Pharmaceutical solvents, fundamentals of solubility and solubilization of drugs. Water treatment processes, sterilization techniques and quality requirements of pharmaceutical water. Parenteral dosage forms and liquid ophthalmics. Surfactants, micelle formation and colloidal systems. Liquid suspensions and emulsions. Stabilization measures in dosage forms.

Literature
Prerequisites / notice:

Language: German and English

Competencies:

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: assessed
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Prerequisites:
Requirements: Lecture courses in basic organic chemistry, biochemistry, and biology

535-0333-00L Pharmaceutical Biology

Objectives:
- The understanding of the biosynthesis of plant-derived natural products. Acquisition of fundamental knowledge on the medical applications of important herbal medicines and of isolated natural products (general disease areas, molecular constituents of medicinal plants and herbal medicines in general, molecular constituents responsible for pharmacological activity, possible mechanisms of action, available clinical data to support medical use).

Content:
The lecture is centered around the discussion of medicinal plants and herbal medicines and their common medical applications. The main areas addressed in the lecture are (a) the structure and biosynthesis of plant constituents (i.e. plant-derived natural products) and (b) the pharmacological effects and therapeutic applications of biogenic drugs of plant origin (herbal medicines based on plant extracts as well as isolated natural products). The basic pathways for the biosynthesis of the most important classes of plant-derived natural products are discussed in detail. Likewise, the molecular basis of the pharmacological effects of medicinal plant extracts (and derived herbal medicines) and their individual constituent components (isolated natural products) is broadly addressed. As part of this discussion the availability of clinical data (or lack thereof) to support specific clinical applications of herbal medicines will be repeatedly highlighted. Potential risks associated with the use of herbal medicines are discussed for selected cases. The lecture is structured according to the major classes of natural products prevalent in medicinal plants and herbal medicines: Carbohydrates, lipids, terpenes, phenolic compounds, alkaloids, essential oils.

535-0525-00L Pharmaceutical Cases

Abstract:
The course places the basic pharmaceutical knowledge acquired to date, particularly in pharmacology, in an applied therapeutic context and encourages interdisciplinary thinking in pharmacy. Weekly practical sessions present and discuss common pharmaceutical case studies that may arise in a pharmacist's daily work.

Objectives:
- Students are able to independently analyse, present, explain, and discuss simple case studies from pharmacy practice based on their basic knowledge of pharmacy, particularly pharmacology.
- Students deepen their knowledge of therapeutic classes, drugs, and treatment guidelines.
- Students are able to analyse the pharmacological profiles of selected drugs in a therapeutic context (e.g., with regard to adverse drug reactions and interactions).
- Students are able to compare different drugs and derive therapy-relevant characteristics.

Content:
Pharmaceutical case studies from different therapeutic fields comprehend following subject areas:
- Indication
- Dosage Form
- Adverse Drug Reactions
- Interactions
- Contraindications

Lecture notes:
Is made available via Moodle.

Prerequisites
The lecture Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

The course takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and discussed in plenary.
### Gene Technology

**Abstract**
The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.

**Objective**
The course gives an overview of current state-of-the-art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the-art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.

**Content**

#### I) Genomics and transcriptomics

- **Methods and Techniques:**
  - Recombinant DNA technology
  - Next generation sequencing methods, sequencing of genomes
  - CRISPR technology

- **Application to human biology:**
  - Functional genomics/transcriptomics
  - Principles of cancer, genetic diseases
  - Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

#### II) Proteomics

- **Methods and Techniques:**
  - Protein cloning and expression
  - The antibody molecule
  - Measurement and determination of biomolecular interactions
  - Protein characterization and engineering
  - Modifications and radioactive labelling

- **Application to human biology:**
  - Protein therapeutics
  - Proteomic approaches for identification of novel disease-related targets and biomarkers

#### III) Drug discovery: Protein-based libraries

- Immune repertoire mining
- Display and selection technologies
  1. antibody phage display
  2. other polypeptide display technologies
  3. small-molecules display: DNA-encoded chemical libraries

**Lecture notes**
The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

### Pharmaceutical Immunology I

**Abstract**
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

**Objective**
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

**Literature**
Janeway's Immunobiology, by Kenneth Murphy et al. (9th or 10th Edition; W.W. Norton & Company).

**Competencies**

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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
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</table>

### Clinical Microbiology

**Abstract**
Thorough knowledge of major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

**Objective**
Thorough knowledge of all major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.
Content
Basics and principles of clinical microbiology:
- host-pathogen interaction
- symptoms and diagnosis of major bacterial pathogens
- therapeutic regimens commonly used against bacterial disease
- major aspects of medical mycology, virology and parasitology
- epidemiology

Literature
- Madigan M.T. et al., Brock Mikrobiologie, Pearson, 15. aktualisierte Auflage 2020
- Kayser F.H. et al., Medizinische Mikrobiologie, Thieme, 14. überarbeitete Auflage 2022

Prerequisites / notice
Basic knowledge of biochemistry, general microbiology, immunology

Competencies

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<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
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<td>535-0210-00L</td>
<td>Radiopharmaceutical Chemistry</td>
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<td>2 credits</td>
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<tr>
<td>Abstract</td>
<td>- Molecular imaging in drug development</td>
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<td>- Radiopharmaceutical syntheses</td>
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<td>- Knowledge of the physical principles of radioactivity</td>
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<td>- Structure and function of radiopharmaceuticals</td>
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<td>- Examples of application in diagnosis and therapy in humans</td>
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<td>- Targeted radionuclide therapy</td>
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<tr>
<td>Objective</td>
<td>- The students know and are able to describe the different imaging procedures in medicine, especially PET and SPET.</td>
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<tr>
<td>- At the end of the lecture, the students are able to explain and describe the physical basics in connection with radioactivity and the different types of radioactive radiation that are relevant in radiopharmacy and nuclear medicine.</td>
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<td>- The students know how radionuclides can be produced and extracted.</td>
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<td>- The students can describe the structure and function of radiopharmaceuticals and are able to develop strategies for the design of new radiopharmaceuticals.</td>
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<td>- The students know selected examples of clinically relevant radiopharmaceuticals and can explain the structure and mechanism of action.</td>
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<td>- The students can discuss and apply the principles of internal dosimetry of systemically applied radiopharmaceuticals using selected examples.</td>
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<tr>
<td>Content</td>
<td>- Introduction to molecular imaging.</td>
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<td>- Radioactive decay, radiation and radionuclides relevant in nuclear medicine.</td>
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<td>- Radionuclide generators</td>
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<td>- Radiopharmaceutical synthesis strategies</td>
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<td>- Heart, brain and tumour diagnostics with radiopharmaceuticals</td>
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<td>- Kinetic modelling with radiopharmaceuticals</td>
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<td>- Tumour therapy with radiopharmaceuticals</td>
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<td>- Dosimetry of radiopharmaceuticals</td>
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<tr>
<td>- Practical aspect of nuclear medicine and radiopharmacy</td>
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<tr>
<td>Literature</td>
<td>Book Title: Fundamentals of Nuclear Pharmacy Authors Gopal B. Saha DOi <a href="https://doi.org/10.1007/978-3-319-57580-3">https://doi.org/10.1007/978-3-319-57580-3</a>.</td>
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<td>- Book Title Radiopharmaceutical Chemistry Editors Jason S. Lewis Albert D. Windhorst, Brian M. Zeglis DOI <a href="https://doi.org/10.1007/978-3-319-98947-1">https://doi.org/10.1007/978-3-319-98947-1</a>.</td>
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Competencies

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<td>Pharmacology and Toxicology I</td>
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<td>3 credits</td>
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<tr>
<td>Abstract</td>
<td>This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.</td>
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<tr>
<td>Objective</td>
<td>The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.</td>
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<tr>
<td>Content</td>
<td>Topics include disease-relevant macroscopic, microscopic, pathobiochemical and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicity, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.</td>
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Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1982 of 2667
Lecture notes
A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

Literature
Recommended reading:

The classic textbook in Pharmacology:
Goodman and Gilman’s The Pharmacological Basis of Therapeutics

Prerequisites / notice
Voraussetzungen: Abschluss Grundstudium

Competencies

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Laboratory Courses

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<tr>
<td>535-0239-00L</td>
<td>Practical Course in Medicinal Chemistry</td>
<td>O</td>
<td>3 credits</td>
<td>7P</td>
<td>J. Hall, C. Halin Winter, J. Scheuermann</td>
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</table>

Abstract
The course comprises experiments relating to concepts of medicinal chemistry including statistical processing, fitting of experimental data, computer modeling of protein structures, experimental measurement of affinity constants and kinetic dissociation constants for protein ligands. The chemical stability of a drug will be studied. Basic gene cloning and protein expression will be introduced.

Objective
Knowledge of experimental methods in drug discovery and development

Analysis of simulated clinical specimens using classical methods of Medical Microbiology (microscopy, culture etc.). Main aims are the detection and identification of bacterial, mycobacterial and mycological pathogens as well as microbial susceptibility testing. Safe lab-technical handling is imperative, because pathogens of risk groups 1 and 2 are cultured. Therefore aseptic techniques need to be learned together with the basics in sterilization, disinfection and preservation.

Basics of Bio-Safety.

Content
Simulated patient specimens representing ca. 50 realistically constructed cases are analysed. The students work in groups and gain insight into the procedures in a routine clinical microbiological laboratory. Using a scriptum, they learn how to identify pathogens and test them for antimicrobial susceptibility. As single groups can work only on a fraction of the cases, results and observations are shared by short presentations through all groups.

Lecture notes
The scriptum (in German) will be distributed at the beginning of the course. It contains all protocols necessary for the practical work

Literature
Prerequisites / notice
Requirements:
Registration for the course until 15 October;
Attendance of the lecture Medicinal Microbiology in the same semester or earlier;
Basic skills in careful laboratory work.

By enrolling in this lab course, students confirm to thoroughly study all safety information and follow instructions.

535-0219-00L Laboratory Course in Pharmaceutical Analytics  O  4 credits  7P  C. Steuer

Abstract
Solving analytical problems; Development and interpretation of analytical methods.

Objective
Solving analytical problems; Development and interpretation of analytical methods.

Content
Solving analytical problems. Development and interpretation of analytical methods.

Literature
Skript Pharmazeutische Analytik Praktikum

Prerequisites / notice
Requirements:
SR 2020: 7 KP Pharmazeutische Analytik 1 and Pharmazeutische Analytik 2 or 36 KP of compulsory lectures 2nd year

By enrolling in this lab course, students confirm to thoroughly study all safety information and follow instructions.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Cooperation and Teamwork fostered

Personal Competencies
Adaptability and Flexibility fostered
Critical Thinking fostered
Integrity and Work Ethics fostered

► Electives

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<td>535-0250-00L</td>
<td>Biotransformation of Drugs and Xenobiotics</td>
<td>W</td>
<td>1</td>
<td>1V</td>
<td>S.-D. Krämer</td>
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</table>

Abstract
Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Objective
Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics.

Content
Toxic reactions of metabolites. Factors which affect the biotransformation.

Lecture notes
Biotransformation of drugs and xenobiotics

Literature

Competencies
Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking fostered

| 535-0344-00L | From Ethnopharmacy to Molecular Pharmacognosy | W    | 1    | 1V    | B. Frei Haller, A. Lardos |

Abstract
Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Objective
Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Content
Introduction into ethnopharmacy and related disciplines: definitions of terms, working methods, research projects, bioprospecting.

Lecture notes
Handouts will be provided.

Literature

Prerequisites / notice
Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.
In assessing, S. Nicolussi fostered The lecture conveys knowledge about the development of the pharmacist profession from ancient times to the present. Some pharmacists

assessed Communication, S. Nicolussi

assessed Fostering Adaptability and Flexibility fostered

assessed After attending the lecture, the students are able to name significant events in the development of the pharmacy profession, pharmacy and

fostered Assessing the important role of the pharmacist in society and the legal conditions in different epochs. It explains what influence the pharmacists had on the development of the pharmaceuticals, but again the pharmaceuticals on the development of the pharmacists. For this purpose, it is shown how much the meaning, the nature, the type and the composition of pharmaceuticals and the knowledge about them changed over time.

The scripts will be sent to the participants via email before the respective lectures

Wird in der ersten Veranstaltung mitgeteilt.

An interest in the history of pharmacy, the pharmacy profession, and medicines is an asset.

In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs.

After attending the lecture, the students are able to name significant events in the development of the pharmacy profession, pharmacy and medicines and to place them in a temporal context. They can list sources for working on questions from the history of pharmacy and evaluate their advantages and disadvantages. This enables them to confidently describe the importance of pharmacy as an independent, supporting pillar of the health system, the history of which has many interfaces with medicine, science, social and cultural history.

The lecture conveys knowledge about the development of the pharmacist profession from ancient times to the present. Some pharmacists who made significant contributions to pharmacy are presented in more detail and their significance for today’s pharmacy is discussed. The social position of pharmacists in society and the legal conditions in different epochs are also discussed. It explains what influence the pharmacists had on the development of the pharmaceuticals, but again the pharmaceuticals on the development of the pharmacists. For this purpose, it is shown how much the meaning, the nature, the type and the composition of pharmaceuticals and the knowledge about them changed over time.

An interest in the history of pharmacy, the pharmacy profession, and medicines is an asset.

Vitamins are essential organic compounds that cannot be synthesized by an organism and hence, they have to be acquired from the diet.

This lecture will give an overview about the application of vitamins in health and disease.

Students should learn about the importance of rational (= evidence-based) pharmacotherapy with herbal extracts and know which factors influence the quality of such medicinal products. The following topics are covered:

- Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed

The topics are explained and critically discussed using various phytopharmaceuticals as examples (see programme below).

Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed

The topics are explained and critically discussed using various phytopharmaceuticals as examples (see programme below).

The topics are explained and critically discussed using various phytopharmaceuticals as examples (see programme below).

The aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products.
Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications. Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested. 

A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period. The lecture 'Vitamins in Health and Disease' will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.

The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

References:
2. - Handbuch Nährstoffe, Burgerstein, Trias Verlag ISBN 978-3-8304-6071-8
4. - recent publications as cited/proposed on the lecture slides

Student learning outcomes:
1. Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:
   - major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
   - the major types of protein-linked glycans and the biosynthetic pathways for their formation
   - how glycoproteins are produced (including the most important expression systems used), glycoengineered and analysed (quality control)
2. Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).
3. Students gain the ability to reflect on roles of glycosylation in various biological contexts.

Literature
- Handbuch Nährstoffe, Burgerstein, Trias Verlag ISBN 978-3-8304-6071-8
- recent publications as cited/proposed on the lecture slides

Prerequisites / notice
Requirements: Basic knowledge in biochemistry and pharmacoology. Ability to read and understand scientific publications in English.
Lecture notes Script will be available.

Literature Recommended textbooks:

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

Abstract The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature

Further references will be provided in the course.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes course website on Moodle


Abstract The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.
The course covers the following topics:

1. Introdcution into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

1. First, basic molecular and cellular mechanisms in nerve cells (excitability, neurotransmission, signal transduction, gene expression, synaptic plasticity) are introduced. Afterwards, their significance for selected neurophysiological processes (learning/memory, sleep, sensory) will be illuminated.
2. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are introduced.
3. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.
4. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

Literature


(available online via ETH library)

Lecture notes

Handouts are deposited online (moodle).

Literature


(available online via ETH library)

Handouts and references therin.
### Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

### Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

### Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

### Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alia.smith@bc.biol.ethz.ch)

### Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

### Competencies

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<tr>
<th>Competencies</th>
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<th>Techniques and Technologies</th>
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<th>Prerequisites / notice</th>
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<tr>
<td>752-4005-00L</td>
<td>Food Microbiology I</td>
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<td>3</td>
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### Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

### Competencies

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<td>Social Competencies</td>
<td>Communication</td>
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### Methods and Technologies

<table>
<thead>
<tr>
<th>Topics</th>
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<tbody>
<tr>
<td>Lipid oxidation, Maillard reaction, structural proteins/enzymes</td>
</tr>
<tr>
<td>Food as complex systems</td>
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<tr>
<td>Chemical reactions and reaction mechanisms</td>
</tr>
<tr>
<td>Selected (possibly changing) chemical topics (e.g. sweeteners, polysaccharides, from olive to margarine, etc.)</td>
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</tbody>
</table>

Links to food analysis, food processing, and nutrition.

### Literature

This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented.

**Lecture notes**

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

**Literature**

Recommendations will be given in the first lecture.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<td>Problem-solving</td>
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<td>Project Management</td>
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**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Handouts will be made available.
- Self-presentation and Social Influence: fostered
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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**Prerequisites / notice**

A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

**Content**

1. History of Food Microbiology
2. Spoilage of Foods
3. Foodborne Disease
4. Food Preservation
5. ViPs of Food Microbiology
6. Overview of Microorganisms in Foods
7. Origin of foodborne Microorganisms
8. Bacteria
9. Yeasts
10. Molds
11. Microbial Spoilage of Foods
12. Intrinsic and Etrinsic Parameters
13. Meats, Seafoods, Eggs
14. Milk and Milk Products
15. Vegetable and Fruit Products
16. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
17. Drinks and Canned Foods
18. Foodborne Disease
19. Significance and Transmission of Foodborne pathogens
20. Staphylococcus aureus
21. Gram-positive Sporeformers (Bacillus & Clostridium)
22. Listeria monocytogenes
23. Salmonella, Shigella, Escherichia coli
24. Vibrio, Yersinia, Campylobacter
25. Brucella, Mycobacterium
26. Parasites
27. Viruses and Bacteriophages
28. Mycotoxins
29. Bioactive Amines
30. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

**Literature**

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

**Prerequisites**

A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

---

**Abstract**

This lecture introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries.

**Objective**

Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

**Content**

This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.

**Lecture notes**

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

**Literature**

M. Schuppler, E. Slack

**Prerequisites / notice**

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!
Compensatory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<td>535-0344-00L</td>
<td>From Ethnopharmacy to Molecular Pharmacognosy</td>
<td>W</td>
<td>1</td>
<td>1V</td>
<td>B. Frei Haller, A. Lardos</td>
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</tbody>
</table>

Abstract
Basic understanding and awareness of ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmacological knowledge for world health.

Objective
Basic understanding and awareness of ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmacological knowledge for world health.

Handouts will be provided.

Lecture notes


Prerequisites / notice

Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies

Analytical Competencies fostered
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies

Communication fostered
Cooperation and Teamwork assessed
Customer Orientation fostered
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed

535-0015-00L History of Pharmacy W 1 credit 1V S. Ruppen

Abstract

In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs.

Objective

After attending the lecture, the students are able to name significant events in the development of the pharmacy profession, pharmacy and medicines and to place them in a temporal context. They can list sources for working on questions from the history of pharmacy and evaluate their advantages and disadvantages. This enables them to confidently describe the importance of pharmacy as an independent, supporting pillar of the health system, the history of which has many interfaces with medicine, science, social and cultural history.

Content

The lecture conveys knowledge about the development of the pharmacist profession from ancient times to the present. Some pharmacists who made significant contributions to pharmacy are presented in more detail and their significance for today’s pharmacy is discussed. The social position of pharmacists in society and the legal conditions in different epochs are also discussed. It explains what influence the pharmacists had on the development of the pharmaceuticals, but again the pharmaceuticals on the development of the pharmacists. For this purpose, it is shown how much the meaning, the nature, the type and the composition of pharmaceuticals and the knowledge about them changed over time.

Literature

An interest in the history of pharmacy, the pharmacy profession, and medicines is an asset.

Competencies

Subject-specific Competencies

Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies

Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered

Social Competencies

Communication fostered
Cooperation and Teamwork assessed
Customer Orientation fostered
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed

535-0360-00L Evidence Based Phytotherapy W 1 credit 1V K. Berger Büter, S. Nicolussi

Abstract

Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed

Objective

Content and aim of the lecture:

Students should learn about the importance of rational (= evidence-based) pharmacotherapy with herbal extracts and know which factors influence the quality of such medicinal products. The following topics are covered:

How are interesting development candidates identified. What are the strategies?
What are the regulatory requirements (traditional use, well-established use, new herbal entities)?
Determination of efficacy from (animal/human studies, biomarkers)
Quality of clinical studies
Pharmacokinetics of phytopharmaceuticals
Safety (toxicity, adverse effects, interactions)
Pharmaceutical quality
Variatel purity (wild collections, cultivation)
Influence of genetic variability on extract quality
Ensuring consistent quality
Which extraction methods?

The topics are explained and critically discussed using various phytopharmaceuticals as examples (see programme below).
535-0021-00L  Vitamins in Health and Disease   W  1 credit  1V  C. Müller

**Abstract**

Vitamins are essential organic compounds that cannot be synthesized by an organism and hence, thy have to be acquired from the diet. This lecture will give an overview about the application of vitamins in health and disease.

**Objective**

The aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products.

**Content**

Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications, Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested. A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period.

The lecture ‘Vitamins in Heath and Disease’ will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.

**Lecture notes**

Hand-outs will be distributed during the lecture (partly in English, partly in German).

**Literature**

Book recommendation: reference books:


Arzneimittel und Mikronährstoffe - Medikationsorientierte Supplementierung
WVG. ISBN 978-3-8477-2779-3

**Prerequisites / notice**

Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.

535-0250-00L  Biotransformation of Drugs and Xenobiotics   W  1 credit  1V  S.-D. Krämer

**Abstract**

Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

**Objective**

Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

**Content**

Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics. Toxic reactions of metabolites. Factors which affect the biotransformation.

**Lecture notes**

Biotransformation of drugs and xenobiotics

**Literature**


535-0310-00L  Glycobiology in Drug Development   W  1 credit  1V  V. I. Otto

**Abstract**

Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.

**Objective**

Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:

- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
- the major types of protein-linked glycans and the biosynthetic pathways for their formation
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

Students gain the ability to reflect on roles of glycosylation in various biological contexts.

**Content**

lecture plan:
1. Glycans - information carriers in biology and pharmacotherapy
2. Glucocerebrosidase and the biosynthesis of N-glycans
3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs
5. gCQA analysis of glycoprotein hormone drugs (sialylated glycoproteins)
6. EPO "the same but different"

**Lecture notes**

The slides used for the lectures will be provided online

**Literature**

- recent publications as cited/proposed on the lecture slides

**Prerequisites / notice**

Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology.
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<th>Molecular Mechanisms of Drug Actions and Targets</th>
<th>W</th>
<th>2 credits</th>
<th>1V</th>
<th>J. Scheuermann</th>
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<tr>
<td>Abstract</td>
<td>On average one drug per year is withdrawn from the market. Using selected examples of such drug failures, the course aims at analyzing and discussing the present explanations of drug actions as well as the design and predictive power of animal models and clinical trials. In addition, the ethical, societal, and economical expectations in new drugs shall be reflected and discussed.</td>
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<tr>
<td>Objective</td>
<td>To develop a critical understanding of the relevance and limitations of the current approaches to explaining and anticipating drug effects.</td>
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<td>Content</td>
<td>In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed the limitations of an extremely reductionist view of atherosclerosis and its prevention by drug therapy. It has also highlighted what high expectations we have in a safe and wide applicability of drugs and of their economical success.</td>
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<td>Abstract</td>
<td>The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.</td>
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<tr>
<td>Objective</td>
<td>The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.</td>
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<tr>
<td>Content</td>
<td>The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.</td>
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</table>

<table>
<thead>
<tr>
<th>Literature</th>
<th>Lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisites / notice</td>
<td>Requirements: basic knowledge in Medicinal Chemistry and Pharmacology. Ability to read and understand scientific publications written in English.</td>
</tr>
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</table>


Further references will be provided in the course.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptable and Flexibility</td>
<td>assessed</td>
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<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

<table>
<thead>
<tr>
<th>535-0022-00L</th>
<th>Computer-Assisted Drug Design</th>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>S. Riniker, G. Landrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.</td>
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<tr>
<td>Content</td>
<td>The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).</td>
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<tr>
<td>Lecture notes</td>
<td>Script will be available.</td>
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</tbody>
</table>

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 1994 of 2667
Subject-specific Competencies

- Fostered

Methods and Mechanics in Medicine

On successful completion of the module the student should be able to:

- Understand physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective.
- Relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system.
- Identify key steps in development underlying neurological syndromes and diseases.

Key skills

- Interpret and critically evaluate original research reports.
- Apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content

- Biocompatible Materials
- Tissue Engineering
- Tissue Biomechanics
- Implants

Lecture notes

- The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation).
- The importance of these processes in the context of developmental diseases is discussed.

Content

- Biocompatible Materials
- Tissue Engineering
- Tissue Biomechanics
- Implants

Lecture notes

- The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes

- The course requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites

- BIO142 Developmental Biology, BIO143 Neurobiology

Literature

- Recommended textbooks:
- BIO142 Developmental Biology, BIO143 Neurobiology

376-0021-00L Materials and Mechanics in Medicine

Abstract

Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective.

Objective

- Apply principles of molecular, cellular, and developmental biology to the development of the nervous system.
- Identify key steps in development underlying neurological syndromes and diseases.

Key skills

- Interpret and critically evaluate original research reports.
- Apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content

- Biocompatible Materials
- Tissue Engineering
- Tissue Biomechanics
- Implants

Lecture notes

- The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation).
- The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes

- The course requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites

- BIO142 Developmental Biology, BIO143 Neurobiology

Literature

- Recommended textbooks:
- BIO142 Developmental Biology, BIO143 Neurobiology

376-1305-00L Development of the Nervous System (University of Zurich)

Abstract

Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective.

Objective

- Apply principles of molecular, cellular, and developmental biology to the development of the nervous system.
- Identify key steps in development underlying neurological syndromes and diseases.

Key skills

- Interpret and critically evaluate original research reports.
- Apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content

- Biocompatible Materials
- Tissue Engineering
- Tissue Biomechanics
- Implants

Lecture notes

- The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation).
- The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes

- The course requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites

- BIO142 Developmental Biology, BIO143 Neurobiology

Literature

- Recommended textbooks:
- BIO142 Developmental Biology, BIO143 Neurobiology

376-1305-00L Molecular Neurophysiology: From Molecules to Systems

Abstract

The course covers the physiology of nerve cells, from the single cell through the neuronal network to the systemic level. The focus is on molecular and cellular mechanisms – synaptic transmission, signal transduction, gene expression, synaptic plasticity.

Objective

- Based on an understanding of molecular and cellular mechanisms, the aim is to provide a deepened insight into neurophysiological processes underlying complex brain functions – learning/memory, sleep, sensory.

Content

- First, basic molecular and cellular mechanisms in nerve cells (excitability, neurotransmission, signal transduction, gene expression, synaptic plasticity) are introduced. Afterwards, their significance for selected neurophysiological processes (learning/memory, sleep, sensory) will be illuminated.

Literature

- The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle.

Prerequisites

- BIO142 Developmental Biology, BIO143 Neurobiology

Literature

- Recommended textbooks:
- BIO142 Developmental Biology, BIO143 Neurobiology

376-1714-00L Biocompatible Materials

Abstract

Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective.

Objective

- Apply principles of molecular, cellular, and developmental biology to the development of the nervous system.
- Identify key steps in development underlying neurological syndromes and diseases.

Key skills

- Interpret and critically evaluate original research reports.
- Apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content

- Biocompatible Materials
- Tissue Engineering
- Tissue Biomechanics
- Implants

Lecture notes

- The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation).
- The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes

- The course requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites

- BIO142 Developmental Biology, BIO143 Neurobiology

Literature

- Recommended textbooks:
- BIO142 Developmental Biology, BIO143 Neurobiology
### Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

### Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

### Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

### Lecture notes
Handouts are deposited online (moodle).

### Literature

(available online via ETH library)

Handouts and references therin.

### 551-0313-00L
**Microbiology (Part I)**

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
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<tbody>
<tr>
<td>W-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
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</tbody>
</table>

**Abstract**
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Objective**
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Content**
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Lecture notes**
Updated handouts will be provided during the class.

**Literature**
Current literature references will be provided during the lectures.

**Prerequisites / notice**
English
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

### 551-0319-00L
**Cellular Biochemistry (Part I)**

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
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</thead>
<tbody>
<tr>
<td>U. Kutay, F. Allain, T. Kleele, I. Zemp</td>
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</table>

**Abstract**
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

**Lecture notes**
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

**Literature**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**Competencies**
Subject-specific Competencies: Concepts and Theories

**Techniques and Technologies**

### 752-1003-00L
**Food Chemistry II**

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
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</thead>
<tbody>
<tr>
<td>L. Nyström, S. Boulos, M. Erzinger</td>
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</tbody>
</table>

**Abstract**
Descriptive chemistry of food constituents (focus on structure-function relationships).

**Objective**
Be able to draw chemical structures of the main ingredients, recognize functional groups in the structures and explain their properties. Understand foods as complex systems and be able to make connections between chemical structures, chemical reactions and their influence on quality.

**Content**
Descriptive chemistry of food constituents (focus on structure-function relationships).

**Topics**
- Lipid oxidation, Maillard reaction, structural proteins/enzymes
- Food as complex systems
- Chemical reactions and reaction mechanisms
- Selected (possibly changing) food chemistry topics (e.g. sweeteners, polysaccharides, from olive to margarine, etc.)

The lectures Food Chemistry I and Food Chemistry II constitute a unit.

**Lecture notes**
The lectures are supplemented with handouts.

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Literature


Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication fostered

752-4005-00L  Food Microbiology I  W  3 credits  2V  M. Loessner, A. Harms

Abstract
This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Objective
The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms. The focus of this first part of the two part lecture (Food Micro II is offered in the FS) will be on the organisms, but also on the factors which determine spoilage and foodborne disease.

Content
1. History of Food Microbiology
2. Overview of Microorganisms in Foods
   2.1 Origin of foodborne Microorganisms
   2.2 Bacteria
   2.3 Yeasts
   2.4 Molds
3. Microbial Spoilage of Foods
   3.1 Intrinsic and Extrinsic Parameters
   3.2 Meats, Seafoods, Eggs
   3.3 Milk and Milk Products
   3.4 Vegetable and Fruit Products
   3.5 Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
   3.6 Drinks and Canned Foods
4. Foodborne Disease
   4.1 Significance and Transmission of Foodborne pathogens
   4.2 Staphylococcus aureus
   4.3 Gram-positive Sporeformers (Bacillus & Clostridium)
   4.4 Listeria monocytogenes
   4.5 Salmonella, Shigella, Escherichia coli
   4.6 Vibrio, Yersinia, Campylobacter
   4.7 Brucella, Mycobacterium
   4.8 Parasites
   4.9 Viruses and Bacteriophages
   4.10 Mycotoxins
   4.11 Bioactive Amines
   4.12 Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

Literature
Recommendations will be given in the first lecture.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Self-presentation and Social Influence fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

376-2017-00L  Biomechanics of Sports Injuries and Rehabilitation  W  3 credits  2V  K.-U. Schmitt, J. Goldhahn

Abstract
This lecture introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries.

Objective
Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

Content
This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focusses on sports injuries.

Lecture notes
Handouts will be made available.

Literature

Prerequisites / notice
A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions would toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

A list of references will be given at the beginning of the course for the different topics presented during the course.

To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

There is no script. Powerpoint presentations will be made available on-line to students.

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

The course will cover diverse topics in modern food biotechnology, including:

- food fermentation (arguably the world's oldest biotechnology)
- the taxonomy and metabolism of microorganisms used in food production
- microbial and fermentation kinetics
- bioreactors for food and ingredient production
- biopreservation
- molecular diagnostics
- safety and regulation of biotechnological ingredients in food production.

At the end of this course, you will be able to identify beneficial/detrimental bacteria associated with food products, execute basic bioinformatic analysis (DNA-based) to identify them, explain the main production (upstream) and purification (downstream) processes of food-relevant microorganisms and ingredients, calculate microbial kinetic parameters, connect key metabolic features with specific application in the food industry (e.g. biopreservation), and understand the general legislation (EU/CH) regarding the use of microorganisms in food.
Competencies Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed
Personal Competencies Critical Thinking assessed

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Pharmaceutical Sciences Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
<td>O</td>
<td>Compulsory</td>
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Key for Hours

<table>
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<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Pharmacy Master

Core Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences. Students work in small groups on a chosen topic and present their work on a one day symposium.

Objective

The main objectives of this course are:

- students develop their scientific reflection (Critical Thinking) and working skills by working independently on a relevant pharmaceutical topic
- students gain in-depth knowledge of the topic investigated
- students train their scientific writing and presentation skills
- students train their ability to plan a project and work in a team

Content

The Course Drug Seminar takes place during the first 7 weeks of the 1. Master semester. It is a compulsory course of the MSc Pharmacy curriculum and an elective course in the MSc PharmSciences.

During the course, students work in small teams on a topic of their choice and elaborate an oral presentation. Each team is tutored by a lecturer of the Institute of Pharmaceutical Sciences. The work is mainly based on literature search/review, but may also involve conducting interviews or site visits, if appropriate. The final presentations of all groups will take place in the framework of a dedicated Symposium held in the middle of the semester.

Prerequisites / notice

Only for students of MSc Pharmacy and MSc Pharmaceutical Sciences.

Competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies

- Analytical Competencies assessed
- Project Management assessed

Social Competencies

- Communication assessed
- Cooperation and Teamwork assessed

Personal Competencies

- Adaptability and Flexibility fostered
- Critical Thinking assessed
- Self-direction and Self-management assessed

535-0041-00L Pharmacology and Toxicology III O 2 2G U. Quitterer, M. Arand, Y. Yamauchi

Abstract

The course is divided into three parts. The first part provides an overview of drugs used for the pharmacotherapy of infectious diseases, osteoporosis, autoimmune diseases and cancer. The second part gives an overview of the field of medical virology, and the third part is focused on pharmacogenomics of drug metabolism and basic concepts of toxicology.

Objective

The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases, osteoporosis, autoimmune diseases and cancer. The course also provides an overview of the fields of medical virology, toxicology, and pharmacogenomics with a special focus on the role of genetic polymorphisms in drug response and adverse effects.

Content

Topics include the pharmacology and pharmacotherapy of infectious diseases, osteoporosis, autoimmune diseases and cancer. Medical virology covers important viral infections and their pharmacotherapy with different classes of antiviral drugs. In the field of pharmacogenomics, the course is focused on examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development. Finally, basic concepts of toxicology are introduced.

Lecture notes

A script is provided for each lecture. The scripts define important and exam-relevant contents of the lectures. Scripts do not replace the lectures.

Literature

Recommended reading:

- The classic textbook in Pharmacology: Goodman and Gilman’s The Pharmacological Basis of Therapeutics
  - Laurence Brunton, Bjorn C. Knollman.
  - 14th edition (2022)
  - ISBN-10: 1264258070

or

- Allgemeine und spezielle Pharmakologie und Toxikologie.
  - 13th edition (2022)
  - Urban & Fischer (Elsevier)
### Pharmacoepidemiology and Drug Safety

**Abstract**
Introduction to the principles, methods and applications of pharmacoepidemiology and drug safety. Drug safety in the pharmaceutical industry and regulatory authorities, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.

**Objective**
- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for clinical pharmacists in hospitals and office pharmacies.
- Perform independently a causality assessment of suspected adverse drug reactions in patients
- Study designs and biostatistics used for the quantitative evaluation of drug safety
- Setup of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals

**Content**
- Historical landmarks of drug safety
- Pharmacovigilance and causality assessment
- Drug safety in premarketing clinical trials
- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding
- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPes)
- Medication errors, clinical pharmacology / clinical pharmacy
- Clinical Decision Support Systems, Interventional Pharmacoepidemiology
- Pharmacoepidemiological databases, 'Big Data'
- Interactive discussion of many real-life examples for each topic

**Lecture notes**
This course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through seminars, case studies in small groups.

**Literature**
- Rothman: Introduction to Epidemiology
- Strom, Kimmel, Hennessy: Textbook of Pharmacoepidemiology
- Gigerenzer: Risk Savvy - How to Make Good Decisions
- Paper References provided in the Scripts
- EMEA Dossier for Humira

### Pharmaceutical Immunology II & Therapeutic Proteins

**Abstract**
In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

**Objective**
- Students know and understand:
  - basic mechanisms and regulation of the immune response
  - the pathogenic mechanisms of the most important immune-mediated disorders
  - the concepts of vaccination and cancer immunotherapy
  - the most frequently used expression systems for the production of therapeutic proteins
  - the use of protein engineering tools for modifying different features of therapeutic proteins
  - the mechanism of action of selected therapeutic proteins and their application
  - basic concepts in the GMP production of therapeutic proteins

**Content**
The course consists of two parts:
In the first part, students will complete their training in Pharmaceutical Immunology. This part particularly focuses on the pathogenic mechanisms of immune-mediated diseases, vaccination and cancer immunotherapy. Deepened knowledge of immunology will be relevant for understanding the mechanism of action of many therapeutic proteins, as well as for understanding one major concern related to the use of protein-based drugs, namely, immunogenicity.

The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

**Lecture notes**
Handouts to the lectures will be available for downloading under http://www.pharma.ethz.ch/scripts/index

**Literature**
- Janeway's Immunobiology, by Kenneth Murphy (9th or 10th Edition)
- Lecture Handouts
- Paper References provided in the Scripts
- EMEA Dossier for Humira

**Prerequisites**
Prerequisites: Either 535-0830-00L Pharmaceutical Immunology I or 551-0317-00L Immunology I
Clinical Chemistry II

Abstract
Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

Objective
Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interpret selected tests.

Content
Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

Lecture notes
Documentation will be available before the lectures electronically.

Literature
- Jürgen Hallbach, Klinische Chemie und Hämatologie für den Einstieg, Thieme Verlag
- Harald Renz, Praktische Labordiagnostik, de Gruyter Verlag
- Walter Guder, Das Laborbuch für Klinik und Praxis, Elsevier Verlag
- Lothar Thomas, Labor und Diagnose, TH Books
- William Marshall, Clinical Chemistry, Mosby Ltd.
- Alan H.B. Wu, Tietz, Clinical Guide to Laboratory Tests, Saunders

Prerequisites / notice
Requirement: basic knowledge in clinical chemistry and laboratory diagnostics

Core Courses (Clinical Subjects)

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<td>O</td>
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Abstract
This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases.

Objective
Students
- know and understand the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, classes of active ingredients and selected, practice-relevant drugs (including indications and the most frequent and important adverse drug reactions, interactions and contraindications).

Content
"Pharmaceutical Care" und "Health Care"; Häufigste Erkrankungen und Therapien der
- Allergologie
- Angiologie und Hämatologie
- Dermatologie
- Endokrinologie und Diabetologie
- Gastroenterologie
- Infektiologie
- Kardiologie
- Neurologie
- Ophthalmologie
- Otorhinolaryngologie
- Pneumologie
- Psychiatrie
- Rheumatologie
- Urologie

Lecture notes
Provided via moodle.

Literature
As stated in the lecture notes.

Prerequisites / notice
Please note that the assessment of this course must be passed (not compensable).

The performance assessment of the course takes place in two written on campus online partial examinations. The overall grade results from the average of the grades of both partial examinations. If the overall grade is unsatisfactory, both partial examinations must be repeated.

The courses Pharmacology and Toxicology I and II and Pathobiology provide indispensable basics which students must master at the beginning of the semester in order to successfully complete the course.

Pharmacology and Toxicology III must be visited at the same time.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

Social Competencies
- Communication: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered
Subject-specific Competencies


Analytical Competencies

The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Creative Thinking

The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Our students are familiar with the various methods and systems for controlled delivery and targeting of drugs, and they are able to critically assess the advantages and disadvantages of these methods in clinical practice.

Personal Competencies

Adaptability and Flexibility

Our students are able to adapt to new situations and changing circumstances. They are able to think creatively and come up with novel solutions to problems.

Communication

Our students are able to communicate effectively with others, both verbally and in writing. They are able to listen actively and express their own ideas clearly and concisely.

Decision-making

Our students are able to make informed decisions, taking into account various factors and perspectives. They are able to evaluate risks and make choices that are consistent with their values and goals.

Integrity and Work Ethics

Our students are committed to ethical behavior in all aspects of their work. They are able to recognize and adhere to professional standards and ethical principles.

Critical Thinking

Our students are able to analyze information and arguments critically, and to evaluate their validity and reliability. They are able to challenge assumptions and question received wisdom.

Leadership and Responsibility

Our students are able to take initiative and responsibility for their actions. They are able to guide others and make decisions that benefit the group as a whole.

Negotiation

Our students are able to negotiate effectively with others, resolving conflicts and reaching agreements that are mutually acceptable.

Sensitivity to Diversity

Our students are able to appreciate and respect differences among people. They are able to work effectively with people from diverse backgrounds and perspectives.

Self-presentation and Social Influence

Our students are able to present themselves effectively in social situations. They are able to influence others and achieve desired outcomes.

Self-direction and Self-management

Our students are able to manage their own time and resources effectively. They are able to set goals and work towards achieving them, even in the face of challenges and obstacles.

Method-specific Competencies


Biotransformation of Drugs and Xenobiotics

Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Biotransformation of Drugs and xenobiotics

Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.


Competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making assessed

Media and Digital Technologies fostered

Problem-solving assessed

Project Management fostered

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation fostered

Leadership and Responsibility fostered

Self-presentation and Social Influence fostered

Sensitivity to Diversity fostered

Negotiation fostered

Personal Competencies

Adaptability and Flexibility assessed

Creative Thinking fostered

Critical Thinking assessed

Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered

Self-direction and Self-management fostered

Further references will be provided in the course.

535-0546-00L Patents

Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

Abstract

Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

Objective

Basic knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

Content

1. Introduction into industrial property (patents, trademarks, industrial designs);
2. Prosecution of patent applications (patentability);
3. Patent information (patent publications, databases, searches);
4. Exploitation and enforcement of patents (possibilities of exploitation, licenses, parallel imports, scope of protection, patent infringement);
5. Peculiarities in pharmaceuticals and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication);
6. Social, political and ethical aspects (patents and prices for medicinal products, traditional knowledge and ethnomedicine, bioprospecting and biopiracy, human DNA inventions);
7. Trademarks, types of trademarks, grounds for refusal, peculiarities of pharma-trademarks.

Lecture notes

A script is provided in electronic form during the lecture.
### Literature

### Prerequisites / notice
None

### Competencies

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<td>Self-presentation and Social Influence</td>
<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

### Content

#### History of Pharmacy
- In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs.
- After attending the lecture, the students are able to name significant events in the development of the pharmacy profession, pharmacy and medicines and to place them in a temporal context. They can list sources for working on questions from the history of pharmacy and evaluate their advantages and disadvantages. This enables them to confidently describe the importance of pharmacy as an independent, supporting pillar of the health system, the history of which has many interfaces with medicine, science, social and cultural history.
- The lecture conveys knowledge about the development of the pharmacist profession from ancient times to the present. Some pharmacists who made significant contributions to pharmacy are presented in more detail and their significance for today's pharmacy is discussed. The social position of pharmacists in society and the legal conditions in different epochs are also discussed. It explains what influence the pharmacists had on the development of the pharmaceuticals, but again the pharmaceuticals on the development of the pharmacists. For this purpose, it is shown how much the meaning, the nature, the type and the composition of pharmaceuticals and the knowledge about them changed over time.

#### From Ethnopharmacy to Molecular Pharmacognosy
- Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.
- Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.
- Traditional medicinal plants of different cultures and their role in modern Western medicine (rational application of traditional uses).

#### Lecture notes
- Handouts will be provided.

#### Literature

#### Prerequisites / notice
- Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.
Lecture notes
Lecture slides and literature for reading and discussions will be available online.

535-0300-00L Molecular Mechanisms of Drug Actions and Targets W 2 credits 1V J. Scheuermann

Abstract
On average one drug per year is withdrawn from the market. Using selected examples of such drug failures, the course aims at analyzing and discussing the present explanations of drug actions as well as the design and predictive power of animal models and clinical trials. In addition, the ethical, societal, and economical expectations in new drugs shall be reflected and discussed.

Objective
To critically appraise the ethical, societal, economical and political expectations in the development of new drugs.

Content
In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed the limitations of an extremely reductionist view of atherosclerosis and it's prevention by drug therapy. It has also highlighted what high expectations we have in a safe and wide applicability of drugs and of their economical success. Torcetrapib is not a single case. In the last 10 years, on average one drug per year was withdrawn from the market due to lack of efficacy, unexpected side effects or toxicity. This clearly shows that the common investigations and the modern understanding of drug actions are often not sufficient to predict the effects a drug will have in large patient populations.

These are the topics of the present course. Using three particularly informative examples of drug failures, the problems encountered and the concepts and informative value of preclinical and clinical studies will be analyzed and discussed. Furthermore, the ethical, societal, economical and political expectations in new drugs shall be reflected.

Lecture notes
Lecture slides and literature for reading and discussions will be available online.

Prerequisites / notice
Requirements: Basic knowledge in Medicinal Chemistry and Pharmacology. Ability to read and understand scientific publications written in English.

535-0310-00L Glycobiology in Drug Development W 1 credit 1V V. I. Otto

Abstract
Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.

Objective
Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:
- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs,
- the major types of protein-linked glycans and the biosynthetic pathways for their formation
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

Students gain the ability to reflect on roles of glycosylation in various biological contexts.

Content
lecture plan:
1. Glycans - information carriers in biology and pharmacotherapy
2. Glucocerebrosidase and the biosynthesis of N-glycans
3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs
5. gCQA analysis of glycoprotein hormone drugs (sialylated glycoproteins)
6. EPO "the same but different"

Lecture notes
The slides used for the lectures will be provided online

Literature
- recent publications as cited/proposed on the lecture slides

Prerequisites / notice
Requirements: Basic knowledge in Immunology, Molecular Biology, Protein and Carbohydrate Chemistry, analytical techniques. Basic knowledge in pharmacology.

535-0021-00L Vitamins in Health and Disease W 1 credit 1V C. Müller

Abstract
Vitamins are essential organic compounds that cannot be synthesized by an organism and hence, they have to be acquired from the diet. This lecture will give an overview about the application of vitamins in health and disease.

Objective
The aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products.
Methods in Drug Design

Book recommendation: reference books:
G. Schneider
Concepts and Theories
Analytical Competencies
Hand-outs will be distributed during the lecture (partly in English, partly in German).
The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the

Lecture notes
Hand-outs will be distributed during the lecture (partly in English, partly in German).

Literature
Book recommendation: reference books:
- Handbuch Nährstoffe, Burgerstein,
  Trias Verlag ISBN 978-3-8304-6071-8

Arzneimittel und Mikronährstoffe - Medikationsorientierte Supplementierung
WVG, ISBN 978-3-647-2779-3

Prerequisites / notice
Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.

535-0360-00L Evidence Based Phytotherapy

Abstract
Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed.

Objective
Content and aim of the lecture:
Students should learn about the importance of rational (= evidence-based) pharmacotherapy with herbal extracts and know which factors influence the quality of such medicinal products.

The following topics are covered:
- How are interesting development candidates identified. What are the strategies?
- What are the regulatory requirements (traditional use, well-established use, new herbal entities)?
- Determination of efficacy from (animal/human studies, biomarkers)
- Quality of clinical studies
- Pharmacokinetics of phytopharmaceuticals
- Safety (toxicity, adverse effects, interactions)
- Pharmaceutical quality
- Varietal purity (wild collections, cultivation)
- Influence of genetic variability on extract quality
- Ensuring consistent quality
- Which extraction methods?

The topics are explained and critically discussed using various phytopharmaceuticals as examples (see programme below).

Content
Effective Zeiten 15.45 - 16.30; 16.45-17.30
Lecture notes
The scripts will be sent to the participants via email before the respective lectures
Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Personal Competencies
Critical Thinking fostered

535-0022-00L Computer-Assisted Drug Design

Abstract
The lecture series provides an introduction to advanced drug design techniques and approaches emphasizing computer-assisted
computer-assisted drug design studies in medicinal chemistry. As a result, they are prepared for professional assessment of
computer-assisted drug design studies in medicinal chemistry projects.

Objective
The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the

Content
The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).

Lecture notes
Script will be available.

Literature
Recommended textbooks:

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered

535-0024-00L Methods in Drug Design

Abstract
The lecture is organized as a two-week block during the practical course "Computer-Assisted Drug Design" (535-0023-00 P), totalling 10 two-hour lectures. It provides an introduction to advanced drug design techniques and approaches emphasizing computer-assisted molecular design.

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Objective

Participants will learn about computational algorithms and advanced experimental approaches to drug discovery and design, including selected actual topics and practical applications. The contents of the lecture will allow for a deeper understanding of modern computer-assisted drug design methods and how they are linked to experimental applications. The main focus is on computational medicinal chemistry, so that participants will be able to use relevant computer-based methods in own research projects.

Literature


Additional selected literature will be provided during the lecture.

Prerequisites / notice

The lecture is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

535-0023-00L  Computer-Assisted Drug Design (Practical Course)  W  4 credits  6P  G. Schneider

Does not take place this semester.

Limited number of participants.

Abstract

The practical course is open for master and graduate students to get an introduction into hands-on computer-assisted drug design. The class includes an introduction to computer-based screening of a virtual compound library, subsequent synthesis of candidate ligands, and biochemically testing for activity on pharmacologically important drug targets.

Objective

Participants become familiar with state-of-the-art methodologies in a real-life computer-aided medicinal chemistry project. Participants work as small teams, perform literature research and discuss recent research findings. A seminar talk is to be given presenting the molecular design strategy chosen and the results obtained during the course.

Content

The course offers the possibility for people with and without computational and or laboratory background to get an introduction into computer-assisted drug design, as well as practical training in a modern chemical laboratory. Using various software suites, the participants will computationally create and screen a virtual compound library for potential active small molecules. The process will involve an introduction to screening a virtual compound library, synthesizing candidate inhibitors, and biophysical testing against a pharmacologically important drug target.

Lecture notes

Detailed information will be handed out during the course.

Literature

Textbook:

Prerequisites / notice

The class is organized as a two-week block course.

The number of participants is limited.

Kick-off meeting and confirmation of registration (Vorbesprechung und Platzvergabe): During the last lecture of the class "Computer-Assisted Drug Design" (535-0022-00)

Ideally, students interested in the course participated and successfully passed the lecture "Computer-Assisted Drug Design" (535-0022-00).

Practical Pharmacy I

<table>
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</table>

Abstract

This course provides basic knowledge relevant to pharmacy and its application in nephrology, phytotherapy, complementary medicine, wound care and pharmaceutical care.

Objective

Students know and understand the therapeutic concepts of the mentioned topics and their application in practice.

(for detailed learning objectives see the guidelines)

Content

- complementary medicine
- phytotherapy
- wound care
- pharmaceutical care
- nephrology

Lecture notes

Provided via myStudies.

Literature

As specified in the lecture notes

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Sensitivity to Diversity

Social Competencies
- Critical Thinking
- Self-awareness and Self-reflection

Personal Competencies


Abstract

This course provides basic clinical and pharmaceutical knowledge and its application for triage, diagnostics and therapy support for the most common diseases in geriatrics, women's health, oncology, paediatrics and neurology (epilepsy). In addition, the role of nutrition in special life situations and in selected health disorders is taught.
Objective
students
- know and understand the pathomechanisms and the clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed.
- can triage patients by applying this knowledge: i.e. analyse simple symptoms and disease patterns, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, drug classes and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

(for detailed learning objectives, see the guideline)

Content
• nutrition
• geriatrics
• neurology (epilepsy)
• oncology
• paediatrics
• women’s health

Lecture notes
Provided via myStudies.

Literature
As specified in the lecture notes

Competencies

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Practical Pharmacy II

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<tr>
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<td>Pharmaceutical Manufacturing in Small Quantities (Compounding)</td>
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<tr>
<td>Abstract</td>
<td>Pharmaceutical Manufacturing relevant for the community pharmacy considering the “GMP-Regeln in kleinen Mengen” of the Pharmacopoeia: The preparation of extemporaneous products covering the most common forms under consideration of their Risks and Quality Assurance.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The students are able to produce pharmaceutical relevant drug Systems without further assistance, lege artis, applying the right techniques and material. The production and packaging has to follow GMP rules and tailored for the patients need. The quality control and correct documentation have to be followed. The students know the most relevant specifications, concentration and dosing ranges of common APIs and excipients. The students are familiar with the relevant literature (Pharmaceutical and legal basis) regarding the Pharmaceutical manufacturing relevant for the community pharmacies.</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Vermittlung der wichtigsten Kenntnisse, Arbeitsschritte und -techniken im Bereich der Arzneimittelherstellung in kleinen Mengen (Formula) mit Fokus auf die Herstellung, Qualitätssicherung und Risikobeurteilung einschliesslich der patientenspezifischen Abgabepraxis.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Safety conceptt: <a href="https://chab.ethz.ch/studium/bachelor1.html">https://chab.ethz.ch/studium/bachelor1.html</a></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Customer Orientation</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

535-5503-00L | Institutional Pharmacy ■ Does not take place this semester. |
| Abstract    | Organisation of institutional environments (emergency hospitals), with special focus on the medication process and institutional pharmaceutical care (continuum of care). |
| Objective   | Students understand the concept of continuum of care and its practical implementation. They know the medication process within an institutional environment. They are able to find the necessary information and deal with problems in connection with pharmaceuticals, to evaluate them and to communicate and documentate their findings adequately. They know how a hospital is organised (procedures, possible problems), responsibilities of the different members of the staff and, most importantly, what the function of a hospital pharmacy is. |
Principals of the organisation of institutional environments (emergency hospitals), with special focus on medication processes and institutional pharmaceutical care (circulation of medication, continuum of care). Hygiene regulations, medical products, applications, drug formularies, patient files, SOAP notes, kardex study. Participation at interdisciplinary visits, internal trainings and doctors' reports as well as visitation of the emergency room. Drug interaction, generic substitution, quality management and pharmacovigilance.

535-5524-00L Clinical Trainings

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-5524-00L</td>
<td>Clinical Trainings</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
</tr>
</tbody>
</table>

A. Gutzeit, D. Stämpfli, P. Wiedemeier

40D

Analytical Competencies

2 credits

fostered

3G

Subject-specific Competencies fostered

fostered

D. Stämpfli

Principals of the organisation of institutional environments (emergency hospitals), with special focus on medication processes and institutional pharmaceutical care (circulation of medication, continuum of care). Hygiene regulations, medical products, applications, drug formularies, patient files, SOAP notes, kardex study. Participation at interdisciplinary visits, internal trainings and doctors' reports as well as visitation of the emergency room. Drug interaction, generic substitution, quality management and pharmacovigilance.

535-5526-00L Injection Techniques and Vaccinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-5526-00L</td>
<td>Injection Techniques and Vaccinations</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
</tr>
</tbody>
</table>

I. S. Vogel Kahmann, C. Halin Winter

3G

Objective

Students will be able to understand the medical-clinical way of thinking for the diagnosis and treatment of acute patients. They complete the change of perspective from the molecular mechanism of action of drugs to the treatment of patients in all its complexity. Using real patient examples, students acquire exemplary knowledge in diagnostics and triage as well as therapy selection and therapy support. They consolidate their understanding of the importance of pharmaceutical care before and after hospitalization.

Content


30 credits

Objective

Die Studierenden erlernen die praktische Durchführung von subkutanen (s.c.) und intramuskulären (i.m.) Injektionen. Sie wissen, wie in Notfallsituationen vorzugehen ist.

Content

Die Lernziele und Inhalte entsprechen dem Fähigkeitsprogramm FPH Impfen und Blutentnahme von PharmaSuisse (ausser venöse Blutentnahmen).

- BLS-AED-SRC Komplettkurs (siehe https://www.slf.ch)
- Vorgehen bei Notfällen (z.B. Herzinfarkt, Schlaganfall, Anaphylaxie u.a.) in der Apotheke
- Vorgehen bei der Versorgung akuter Wunden
- Injektionstechniken: Materialkunde, Hygienevorschriften und Desinfektion, Kommunikation mit Patienten, Vor- und Nachbereitung einer Injektion, praktische Durchführung von subkutanen Injektionen und intramuskulären Injektionen
- Theorie und praktische Aspekte bei der Durchführung von subkutanen Blutentnahmen
- Impfungen (z.B. Lesen von Impfausweisen, Erstellen eines individuellen Impfschemas, Impfdebate)

Wird auf mystudies veröffentlicht.

Schutzkonzept: https://chab.ethz.ch/studium/bachelor1.html

Literature

Wird im Skript angegeben.

Competencies

Subject-specific Competencies

Concepts and Theories asessed

Techniques and Technologies assessed

Analytical Competencies assessed

Decision-making assessed

Media and Digital Technologies assessed

Problem-solving assessed

Communication fostered

Customer Orientation fostered

Sensitivity to Diversity fostered

Negotiation fostered

Adaptability and Flexibility fostered

Critical Thinking fostered

Integrity and Work Ethics fostered

Compensatory Courses

The elective courses can be used as compensatory courses.

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Master's Thesis

Number | Title               | Type | ECTS | Hours | Lecturers
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0660-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>40D</td>
<td></td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed
to begin with their master thesis:

a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
During the Master’s thesis students prove their ability to independent, structured scientific work. The Master’s thesis is usually carried out in a subject area of Pharmaceutical Sciences as chosen by the student.

Objective
In the Master Thesis students prove their ability to independent, structured and scientific working.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td></td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical Competencies</td>
<td></td>
</tr>
<tr>
<td>Decision-making</td>
<td></td>
</tr>
<tr>
<td>Problem-solving</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td></td>
</tr>
</tbody>
</table>

| Social Competencies                        |          |
| Communication                              |          |
| Cooperation and Teamwork                   |          |
| Sensitivity to Diversity                   |          |

| Personal Competencies                      |          |
| Adaptability and Flexibility               | Fostered |
| Creative Thinking                          |          |
| Critical Thinking                          |          |
| Integrity and Work Ethics                  |          |
| Self-awareness and Self-reflection         | Fostered |
| Self-direction and Self-management         |          |

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0135-AAL</td>
<td>Clinical Chemistry I</td>
<td>E-</td>
<td>1</td>
<td>2R</td>
<td>M. Hersberger</td>
</tr>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
<td></td>
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</tr>
</tbody>
</table>

| Abstract | Introduction into fundamentals of laboratory diagnostics and overview of the laboratory parameters concerning inflammation, lipid metabolism, myocardial infarction, diabetes, kidney function, urinary diagnostics, liver function, blood coagulation, blood count, therapeutic drug monitoring and drugs of abuse screening. |
| Objective | Overview of the possibilities and limitations in clinical laboratory diagnostics. Indications and methods of everyday parameters are known. |
| Content  | Introduction into medical laboratory diagnostics: immunochemical methods, diagnostics of inflammation, acute myocardial infarction, lipid metabolism, diabetes, kidney function and urinary diagnostics, blood coagulation, blood count, therapeutic drug monitoring, drugs of abuse screening, common diagnostics of liver diseases, point-of-care diagnostics. |

| 535-0440-AAL | Quality Management in Pharmaceutical Business | E-   | 1    | 2R    | A. Sterchi |
|             | Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. |
|             | Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit. |

| Abstract | The students know the relevance and the role of quality assurance measures to assure quality, efficacy and safety of drugs. The students know the most important Swiss regulations, including the associated European regulations, which are relevant from a quality assurance point of view and they are able to interpret the content of this regulations. |

| 406-0603-AAL | Stochastics (Probability and Statistics) | E-   | 4    | 9R    | M. Kalisch |
|             | Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. |

| Abstract | Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme. |
| Objective | The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R". |
| Content  | From "Statistics for research" (online) |
|          | Ch 1: The Role of Statistics |
|          | Ch 2: Populations, Samples, and Probability Distributions |
|          | Ch 3: Binomial Distributions |
|          | Ch 6: Sampling Distribution of Averages |
|          | Ch 7: Normal Distributions |
|          | Ch 8: Student's t Distribution |
|          | Ch 9: Distributions of Two Variables |
|          | From "Introductory Statistics with R (online)" |
|          | Ch 1: Basics |
|          | Ch 2: The R Environment |
|          | Ch 3: Probability and distributions |
|          | Ch 4: Descriptive statistics and tables |
|          | Ch 5: One- and two-sample tests |
|          | Ch 6: Regression and correlation |
### Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

### Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Methods and Technologies</th>
<th>Subjective Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

### Pharmacy Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

<table>
<thead>
<tr>
<th>ECTS</th>
<th>European Credit Transfer and Accumulation System</th>
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<tbody>
<tr>
<td></td>
<td>Special students and auditors need special permission from the lecturers.</td>
</tr>
</tbody>
</table>
### Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
</tr>
</tbody>
</table>

**Abstract**
Research colloquium

**Objective**
The goal of this event is to bring you closer to current day research in all fields of physics. In each semester we have a set of distinguished speakers covering the full range of topics in physics. As a participating student should learn how to follow a research talk. In particular, you should be able to extract key points from a colloquium where you don't necessarily understand every detail that is presented.

### Physics (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
First Year Compulsory Courses

First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10 credits</td>
<td>6V+3U</td>
<td>L. Kobel-Keller</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The ability to work with the basics of calculus in a mathematically rigorous way.</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>402-1701-00L</td>
<td>Physics I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>K. Ensslin</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course gives a first introduction to Physics with an emphasis on classical mechanics.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000</td>
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</table>

First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>S. Zerbes</td>
</tr>
</tbody>
</table>
Second and Third Year Compulsory Courses

Examination Blocks

Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>Ö. Imamoglu</td>
</tr>
</tbody>
</table>

Abstract
- Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.

Objective
- Working knowledge of functions of one complex variables; in particular applications of the residue theorem.

Literature
- B. Palka: "An introduction to complex function theory."
- Th. Gamelin: Complex Analysis. Springer 2001
- D. Salamon: "Funktionentheorie". Birkhauser, 2011. (In German)
- K.Jaenich: Funktionentheorie. Springer Verlag
- R.Remmert: Funktionentheorie I. Springer Verlag
- E.Hille: Analytic Function Theory. AMS Chelsea Publications

402-2203-01L | Classical Mechanics   | O    | 7 credits | 4V+2U | M. Gaberdiel        |

Abstract
- A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

Objective
- Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies

402-2883-00L | Physics III           | O    | 7 credits | 4V+2U | S. Johnson         |

Abstract
- An introductory course to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.

Objective
- Einführung in die Quantenphysik: Planck’sche Strahlung (Wärmestrahlung), Photonen, Photolelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohsche Atommodell, de-Broglie Materiewellen.
- Optik-Wellenoptik; Linsen, Abbildungssysteme, Brechung und Fermatsches Prinzip, Beugung, Interferenz, Fabry-Perot, Interferometer, Spektrometer.
- Quantenmechanik: Dualismus Teilchen-Welle, Wellenfunktionen, Operatoren, Schrödinger-Gleichung, Potentialstufe und Potentialkasten, harmonischer Ozillator
- Statistische Physik: Wahrscheinlichkeitsverteilungen, Ideales Gas, #aqipartitionsgesetz, Zustandssichste, Maxwell-Boltzmann-Verteilung, Fermi-Dirac-Statistik für Fermionen, Bose-Einstein-Statistik für Bosonen, Elektronengas, Herleitung Planck’sche Strahlungsgesetz (Photonen)gase

Lecture notes
- Im Rahmen der Veranstaltung werden die Foli en in elektronischer Form zur Verfügung gestellt. Ergänzendes Buch wird als Pflichtlektüre empfohlen. Es wird kein Skript in der Vorlesung verteilt.
### Examination Block Ila

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-2333-00L</td>
<td>Mathematical Methods of Physics I</td>
<td>O</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>P. Hintz</td>
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</table>

**Abstract**


### Examination Block Iib

Offered in the Spring Semester

### Other Compulsory Courses

#### Quantum Mechanics I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0205-00L</td>
<td>Quantum Mechanics I</td>
<td>O</td>
<td>8 credits</td>
<td>3V+2U</td>
<td>M. Krstic Marinkovic</td>
</tr>
</tbody>
</table>

**Abstract**


**Applications**

Simple potentials in wave mechanics, scattering and resonance, harmonic oscillator, hydrogen atom, and perturbation theory.

**Social Competencies**

Communication fostered

Cooperation and Teamwork fostered

Customer Orientation fostered

Leadership and Responsibility fostered

Self-presentation and Social Influence fostered

Sensitivity to Diversity fostered

Negotiation fostered

**Personal Competencies**

Adaptability and Flexibility fostered

Critical Thinking fostered

Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered

Self-direction and Self-management fostered

### Other Compulsory Courses ONLY for Programme Regulations 2016

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0205-10L</td>
<td>Quantum Mechanics I</td>
<td>O</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>M. Krstic Marinkovic</td>
</tr>
</tbody>
</table>

**Abstract**


**Applications**

Simple potentials in wave mechanics, scattering and resonance, harmonic oscillator, hydrogen atom, and perturbation theory.

**Social Competencies**

Communication fostered

Cooperation and Teamwork fostered

Customer Orientation fostered

Leadership and Responsibility fostered

Self-presentation and Social Influence fostered

Sensitivity to Diversity fostered

Negotiation fostered

**Personal Competencies**

Adaptability and Flexibility fostered

Critical Thinking fostered

Integrity and Work Ethics fostered

Self-awareness and Self-reflection fostered

Self-direction and Self-management fostered
Content: The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.

Lecture notes: Auf Moodle

Literature:
- G. Baym, Lectures on Quantum Mechanics
- E. Merzbacher, Quantum Mechanics
- L.I. Schiff, Quantum Mechanics and Path Integrals
- R. Feynman and A.R. Hibbs, Quantum Mechanics
- J.J. Sakurai: Modern Quantum Mechanics
- A. Messiah: Quantum Mechanics
- S. Weinberg: Lectures on Quantum Mechanics

Competencies:

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Core Courses

Core Courses in Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0263-00L</td>
<td>Astrophysics I</td>
<td>W</td>
<td>8</td>
<td>3V+2U</td>
<td>A. Refregier</td>
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<td></td>
<td>Physics BSc students with programme regulations 2016 need to register for &quot;402-0263-10L Astrophysics&quot;.</td>
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<tr>
<td>Abstract</td>
<td>This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.</td>
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<tr>
<td>Objective</td>
<td>The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.</td>
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<tr>
<td>Literature</td>
<td>Astrophysics for physicist, Arnab Ray Choudhuri</td>
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<tr>
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<td>Method-specific Competencies</td>
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<td>Analytical Competencies: assessed</td>
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<td>Decision-making: fostered</td>
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<td>Media and Digital Technologies: fostered</td>
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<td></td>
<td>Problem-solving: assessed</td>
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<td>Project Management: fostered</td>
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<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>402-0255-00L</td>
<td>Introduction to Solid State Physics</td>
<td>W</td>
<td>8</td>
<td>3V+2U</td>
<td>A. Zheludev</td>
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<td>Physics BSc students with programme regulations 2016 need to register for &quot;402-0255-10L Einführung in die Festkörperphysik&quot;.</td>
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<tr>
<td>Abstract</td>
<td>The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, and magnetism.</td>
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<tr>
<td>Objective</td>
<td>Introduction to Solid State Physics.</td>
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</tr>
<tr>
<td>Content</td>
<td>The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, thermal properties of insulators; metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism.</td>
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<tr>
<td>Lecture notes</td>
<td>The script will be available on moodle.</td>
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<td></td>
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</table>
| Literature | C. Kittel, Festkörperphysik
|            | Ashcroft & Mermin, Festkörperphysik |      |      |       |            |
| Prerequisites / notice | | Voraussetzungen: Physik I, II, III wünschenswert | | | |
| Competencies | Subject-specific Competencies |      |      |       |            |
|            | Concepts and Theories: assessed          |      |      |       |            |
|            | Analytical Competencies: assessed        |      |      |       |            |
|            | Decision-making: assessed                 |      |      |       |            |
|            | Media and Digital Technologies: fostered |      |      |       |            |
|            | Problem-solving: assessed                 |      |      |       |            |
|            | Project Management: fostered             |      |      |       |            |
|            | Creative Thinking: assessed               |      |      |       |            |
|            | Critical Thinking: assessed               |      |      |       |            |
|            | Integrity and Work Ethics: assessed       |      |      |       |            |

Core Courses in Experimental Physics ONLY for Programme Regulations 2016

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<tr>
<th>Number</th>
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<tr>
<td>402-0263-10L</td>
<td>Astrophysics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>A. Refregier</td>
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<td>Only for Physics BSc, Programme Regulations 2016.</td>
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</table>
Abstract
This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.

Objective
The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.

Literature
Astrophysics for physicists, Arnab Ray Choudhuri

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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402-0255-10L Introduction to Solid State Physics

Only for Physics BSc, Programme Regulations 2016.

Abstract
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, and magnetism.

Objective
Introduction to Solid State Physics.

Content
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism.

Lecture notes
The script will be available on moodle.

Literature
C. Kittel, Festkörperphysik
Ashcroft & Mermin, Festkörperphysik

Prerequisites / notice
Voraussetzungen: Physik I, II, III wünschenswert

Electives

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<td>402-0347-00L</td>
<td>Applications of Physics in Medicine - An Introduction to Medical Physics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>A. J. Lomax, F. Albertini-Cirelli, J. Hrbáček, D. Meer, S. Safai, U. Schneider, Y. Zhang</td>
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</tbody>
</table>

Abstract
Medical physics is a fascinating scientific discipline, providing many professional opportunities to apply physics to the care of patients, either in the clinic or in industry. It is also an area allowing for exciting, interesting and fulfilling areas of research. It is the aim of this course to give bachelor physics students an insight into the wide spectrum of medical applications of physics.

Objective
To provide physics students with an insight into the many and varied applications of physics in medicine. At the end of the course, students will be aware of the major topics in medical physics and its role in hospitals, industry and research.

Content
The course consists of 13 double lectures (2x45 mins), with an additional 1 hour tutorial associated with each lecture and is aimed at bachelor physics students in their last year of studies. Topics covered are:
- History and background to medical physics
- Physics background to medical applications and measurement techniques
- The physics of medical imaging
- The physics of radiotherapy
- Computer and image assisted medical interventions
- Medical physics in the clinic, industry and research.

Prerequisites / notice
An interest in medical applications of physics.

402-0883-63L Symmetries in Physics

Abstract
The course gives an introduction to symmetry groups in physics. It explains the relevant mathematical background (finite groups, Lie groups and algebras as well as their representations), and illustrates their important role across modern physics.

Objective
The aim of the course is to give a self-contained introduction into finite group theory as well as Lie theory from a physicists point of view. Abstract mathematical constructions will be illustrated with examples from physics.

Content
Finite group theory, including representation theory and character methods; applications to crystallography and solid state physics. The symmetric group and the structure of its representations; applications to identical particles. Clifford algebras; application to relativistic wave equations equations. Simple Lie algebras and their finite-dimensional representations. Description of representations of SU(N) in terms of Young diagrams; applications in particle physics.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<tr>
<td>assessed</td>
<td>fostered</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Problem-solving</td>
</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
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</tbody>
</table>

402-0247-00L Electronics for Physicists I (Analogue)

Abstract
Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology

Objective
The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.
Fostered
Part I of this course covers the energy-related topics in this two-semester course. The importance of energy to life and our modern culture

Fostered

Creative Thinking
The Physics of Energy, R.L. Jaffe, W. Taylor, 2018

Fostered
Cooperation and Teamwork
P. Morf

Fostered

Problem-solving
Fostered

Concepts and Theories
Fostered

Techniques and Technologies
Fostered

S. P. Quanz

Fostered

Critical Thinking
Fostered

Lecture Series: Space Research and Exploration

Fostered

Why is energy important for life, economy and our society?

Fostered


Fostered

Energy and Civilization: A History, V. Smil, 2018

Fostered

Clean Disruption of Energy and Transportation, T. Seba 2014

Fostered

The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Fostered

14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Fostered


Fostered

12. Life Cycle Assessment of Energy Technologies – problems and possibilities

Fostered

11. Energy Systems – how everything can play together

Fostered


Fostered

9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?

Fostered

8. Energy Storage – the need to increase capacity and for new technologies

Fostered

7. Breeding and Nuclear Fusion – can it work at all?

Fostered

6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology

Fostered

5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change

Fostered

4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts

Fostered

3. Coal, oil and natural gas – fossil fuels

Fostered

2. Energy and making use of it – a short history of energy use and an overview on energy technologies

Fostered

1. Introduction to Energy – what it is all about

Fostered

The Physics of Energy, R.L. Jaffe, W. Taylor, 2018

Fostered

Clean Disruption of Energy and Transportation, T. Seba 2014

Fostered

Energy and Civilization: A History, V. Smil, 2018

Fostered


Fostered

Basics of Physics applied to Energy and Energy Technology.

Fostered

Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.

Fostered

Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.
<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<td>Problem-solving</td>
<td>Project Management</td>
<td>Negotiation</td>
<td>assessed</td>
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<td>Problem-solving</td>
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<td>Self-awareness and Self-reflection</td>
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### Course Descriptions

<table>
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<th>Type</th>
<th>Credits</th>
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<tbody>
<tr>
<td>402-0890-00L</td>
<td>Introduction to Computational Physics</td>
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<td>2V+2U</td>
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<td></td>
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<td>A. Adelmann</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td>This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td>Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td>Lecture notes and slides are available online and will be distributed if desired.</td>
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<tr>
<td></td>
<td>Literature</td>
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<td>Literature recommendations and references are included in the lecture notes.</td>
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<td></td>
<td>Prerequisites / notice</td>
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<td>Lecture and exercise lessons in English, exams in German or in English</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>151-0109-00L</td>
<td>Turbulent Flows</td>
<td>W</td>
<td>4</td>
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<td></td>
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<td></td>
<td></td>
<td>P. Jenny</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td>Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td>Properties of laminar, transitional and turbulent flows.</td>
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<td></td>
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<td>- Origin and control of turbulence. Instability and transition.</td>
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<td>- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.</td>
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<td>- Scalings, homogeneous isotropic turbulence, energy spectrum.</td>
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<td>- Turbulent free shear flows. Jet, wake, mixing layer.</td>
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<td>- Wall-bounded turbulent flows.</td>
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<td>- Turbulent flow computation and modeling.</td>
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<td>Lecture notes</td>
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<td>Lecture notes are available</td>
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<td>151-0221-00L</td>
<td>Introduction to Modeling and Optimization of</td>
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<td></td>
<td>Sustainable Energy Systems</td>
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<td></td>
<td>G. Sansavini, A. Bardow, S. Moret</td>
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<td></td>
<td>Abstract</td>
<td></td>
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<td>This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.</td>
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<td>Objective</td>
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<td>At the end of this course, students will be able to:</td>
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<td>- define and quantify the key performance indicators of sustainable energy systems;</td>
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<td>- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;</td>
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<td>- apply the acquired knowledge to tackle the challenges of the energy transition.</td>
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<td></td>
<td>In the course “Introduction to Modeling and Optimization of Sustainable Energy Systems”, the competencies of process understanding, system understanding, modeling, concept development, data analysis &amp; interpretation and measurement methods are taught, applied and examined. Programming is applied.</td>
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<td>The global energy transition: Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
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<td>Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.</td>
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<tr>
<td>101-0289-00L</td>
<td>Applied Glaciology</td>
<td>W</td>
<td>4</td>
<td>2G</td>
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<td></td>
<td>D. Farinotti, A. Bauder, M. Werder</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>The course transmits fundamental knowledge for treating applied glaciological problems. Topics include glacier-climate interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td>The objectives of the courses are to:</td>
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<td>- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;</td>
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<td>- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;</td>
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<td>- generate the own computer code to solve the above case studies, and interpret the results;</td>
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<td>- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.</td>
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</tbody>
</table>
The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Digital lecture handouts will be distributed prior to each class.

Links to relevant literature will be provided during the classes.

Completed BSc studies. Basic knowledge in computer scripting in any language (e.g., Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Communication
Cooperation and Teamwork
Self-presentation and Social Influence
Sensitivity to Diversity
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Signals and Systems
W 4 credits 2V+2U A. Carron

Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.


Logical Competencies
Method-specific Competencies
Social Competencies
Personal Competencies

151-0575-01L Signals and Systems W 4 credits 2V+2U A. Carron

Abstract
Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

Objective
Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.

Content

Lecture notes
Lecture notes available on course website.

Prerequisites / notice
Control Systems I is helpful but not required.

Microsystems I: Process Technology and Integration W 6 credits 3V+2U M. Haluska, C. Hierold

Abstract
Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).

Objective
Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (= process flow).

Content
- Introduction to Microsystems Technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific Microsystems Technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

Application of selected technologies will be demonstrated on case studies.

Lecture notes
Handouts (available online).

Prerequisites / notice
Prerequisites: Physics I and II

151-0621-00L Microsystems I: Process Technology and Integration W 6 credits 3V+2U M. Haluska, C. Hierold

151-0913-00L Introduction to Photonics W 4 credits 2V+2U R. Quidant, J. Ortega Arroyo

Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel coefficients
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Applications of optical tweezers

VII- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

Lecture notes
Class notes and handouts
Literature
Optics (Hecht) - Pearson
Prerequisites / notice
Physics

Competencies
Subject-specific Competencies
Method-specific Competencies
Personal Competencies
Concepts and Theories
Techniques and Technologies
Analytical Competencies
Creative Thinking
assessed
assessed
assessed
assessed
assessed

252-0061-00L Systems Programming and Computer Architecture W 7 credits 4V+2U A. Klomovic, T. Roscoe

Abstract
Introduction to systems programming, C and assembly language, floating point arithmetic, basic translation of C into assembler, compiler optimizations, manual optimizations. How hardware features like superscalar architecture, exceptions and interrupts, caches, virtual memory, multicore processors, devices, and memory systems function and affect correctness, performance, and optimization.

Objective
The course objectives are for students to:

1. Develop a deep understanding of, and intuition about, the execution of all the layers (compiler, runtime, OS, etc.) between programs in high-level languages and the underlying hardware: the impact of compiler decisions, the role of the operating system, the effects of hardware on code performance and scalability, etc.

2. Be able to write correct, efficient programs on modern hardware, not only in C but high-level languages as well.

3. Understand Systems Programming as a complement to other disciplines within Computer Science and other forms of software development.

This course does not cover how to design or build a processor or computer.
This course provides an overview of "computers" as a platform for the execution of (compiled) computer programs. This course provides a programmer's view of how computer systems execute programs, store information, and communicate. The course introduces the major computer architecture structures that have direct influence on the execution of programs (processors with registers, caches, other levels of the memory hierarchy, supervisor/kernel mode, and I/O structures) and covers implementation and representation issues only to the extent that they are necessary to understand the structure and operation of a computer system.

The course attempts to expose students to the practical issues that affect performance, portability, security, robustness, and extensibility. This course provides a foundation for subsequent courses on operating systems, networks, compilers and many other courses that require an understanding of the system-level issues. Topics covered include: machine-level code and its generation by optimizing compilers, address translation, input and output, trap/event handlers, performance evaluation and optimization (with a focus on the practical aspects of data collection and analysis).

Lecture notes
- C programming
- Integers
- Pointers and dynamic memory allocation
- Basic computer architecture
- Compiling C control flow and data structures
- Code vulnerabilities
- Implementing memory allocation
- Linking
- Floating point
- Optimizing compilers
- Architecture and optimization
- Caches
- Exceptions
- Virtual memory
- Multicore
- Devices

Literature
The course is based in part on "Computer Systems: A Programmer's Perspective" (3rd Edition) by R. Bryant and D. O'Hallaron, with additional material.

Prerequisites / notice
252-0029-00L Parallel Programming
252-0028-00L Design of Digital Circuits

Abstract
This course acquaints students with core knowledge in computer graphics, image processing, multimedia and computer vision. Topics include: Graphics pipeline, perception and camera models, transformation, shading, global illumination, texturing, sampling, filtering, image representations, image and video compression, edge detection and optical flow.

Objective
This course provides an in-depth introduction to the core concepts of computer graphics, image processing, multimedia and computer vision. The course forms a basis for the specialization track Visual Computing of the CS master program at ETH.

Content
Course topics will include: Graphics pipeline, perception and color models, camera models, transformations and projection, projections, lighting, shading, global illumination, texturing, sampling theorem, Fourier transforms, image representations, convolution, linear filtering, diffusion, nonlinear filtering, edge detection, optical flow, image and video compression.

In theoretical and practical homework assignments students will learn to apply and implement the presented concepts and algorithms.

Lecture notes
A scriptum will be handed out for a part of the course. Copies of the slides will be available for download. We will also provide a detailed list of references and textbooks.

Literature

Abstract
This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.

2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).

3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.

4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality

5. Explain what bad design is and why it matters.

6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".

7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.

8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.

9. Explain what data independence is all about and didn't age a bit since the 1970s.

10. Explain, in the big picture, how a relational database is physically implemented.

11. Know and deal with the natural syntax for relational data, CSV.

12. Explain the data cube model including slicing and dicing.

13. Store data cubes in a relational database.

14. Map cube queries to SQL.

15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logic

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
The courses covers the foundations of design and analysis of algorithms and data structures, including graph theory and graph problems. It also introduces generic and parallel programming.

Understanding design, analysis and implementation of fundamental algorithms and data structures. Overview of the concepts of generic and parallel programming. Hands-on experience with implementing the aforementioned in C++.

Asymptotic runtime (algorithmic complexity)
- Fundamental algorithmic problems, e.g. searching, sorting, shortest paths, spanning trees
- Classical data structures, e.g. search trees, balanced trees, heaps, hash tables
- Graph theory and graph problems
- Problem solving strategies as design patterns for algorithms, e.g. induction, divide and conquer, backtracking, dynamic programming
- Generic programming: C++ templates higher-order functions, lambdas, closures
- Parallel programming: (in)dependence of computations, parallelism and concurrency, shared memory, races, mutual exclusion, communication and synchronisation

Knowledge obtained in the lecture is deepened through practical and/or programming exercises (C++, Code Expert).

All material (slides, lecture recordings, examples, exercises, etc.) will be published on the course website.

Prerequisite: Computer Science I

Student should be able to:
- Apply fundamental concepts in solid state physics to describe and explain the behavior of different types of materials, including the ability to make semi-quantitative assertions about relevant physical quantities.
- Analyze and evaluate different models and approaches to describe specific material properties, and appreciate the pertinence of these models to real-world applications, including the ability to make numerical estimates of the relevant parameters.
- Explain the working principles of a range of devices that take advantage of the physical properties of materials, including electronic, photonic, and magnetic devices.
- Develop an appreciation for the role of solid state physics in modern society and technology, and understand the importance of continued research and development in this field for future technological advancements.
Understanding the electronic properties of solids is at the heart of modern society and technology. The aim of this course is to provide fundamental physical concepts that allow one to relate the electronic structure of different types of materials to their electrical, optical, and magnetic behavior as well as the functioning of basic electronic, photonics, and magnetic devices. Beyond fundamental curiosity, such level of understanding is required in order to develop and appropriately describe new classes of materials for future technology applications. The course is divided in six parts.

PART I: The electronic structure of metals, semiconductors, and insulators
Revision of classical concepts: electric fields and currents, Ohm’s and Drude’s model of electrical conductivity, Hall effect, thermoelectric effects.
Revision of quantum mechanical concepts: Electron bands, Fermi statistics, Fermi energy and Fermi surface, density of states in k-space and as a function of energy.

PART II: Semiconductors: concepts and devices

PART III: Dielectric properties of insulators

PART IV: Interaction of electromagnetic waves with matter
The electromagnetic (EM) spectrum. Electromagnetic waves in vacuum; Energy, momentum, and angular momentum of EM waves; Sources of EM radiation; EM waves in matter. The refractive index. Transmission, Reflection, and Refraction from a microscopic point of view. Optical anisotropy, Optical activity, Dichroism. Optical properties of crystalline insulators and semiconductors, glasses, and metals.

PART V: Photonic devices
Photodiodes, photovoltaic cells, light emitting devices (LEDs), Laser diodes, displays, optical fibers.

PART VI: Magnetism

Lecture notes in English, available for download at http://www.intermag.mat.ethz.ch/education.html

Literature

C. Kittel, Introduction to Solid State Physics (Wiley, 2005), also printed in German. General text that covers many arguments from the point of view of condensed matter physics.


D. A. Neamen, Semiconductor Physics and Devices (McGraw-Hill, 2012). General treatment of semiconductor physics and devices, including both basic and more advanced topics.


Introduction to optics and light waves: E. Hecht, Optics (Lehmanns);

Optoelectronic devices: D. A. Neamen (see above); Simon Sze, Physics of Semiconductor Devices (Wiley)


Physik I and II, Materialphysik I and II. The lecture will be given in English. The script will be available in English.

Prerequisites / notice

Material-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies

Communication assessed

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

Competencies

4 credits

Thermal and Transport Properties

Abstract
This course will introduce mass transport, heat conduction, charge transport, and flow in viscous liquids, with emphasis on their shared foundation in diffusive processes.

Objective
Students will learn how to create models describing transport processes. They will solve the resulting equations both analytically and numerically. They will apply these results to design materials processes and understand real-life experiments. A key takeaway will be the ability to construct simple order-of-magnitude estimates and scaling relationships that can be applied to efficient data analysis and design.

Lecture notes
A script in English will be provided on the Moodle course website

327-0515-00L

Autumn Semester 2024

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### Competencies

#### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

#### Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

#### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### 401-2813-00L Programming Techniques for Scientific Simulations I

**W 5 credits 4G R. Käppeli**

**Abstract**

This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.

**Objective**

The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

### 401-2283-00L Analysis III (Measure Theory)

**W 6 credits 3V+2U F. Da Lio**

**Abstract**

Measure and integration theory, including: Caratheodory's theorem, Lebesgue measure, Radon measure, Hausdorff measure, convergence theorems, L^p spaces, Radon-Nikodym theorem, product measure and Fubini's theorem

**Objective**

Basics of abstract measure and integration theory

**Content**

- Measure Spaces (Lebesgue Measure, Hausdorff Measure, Radon Measure)
- Measurable Functions: definition and properties
- Integration: definition, properties, theorems of convergence, Lebesgue L^p spaces
- Product Measures and Multiple Integrals. Fubini and Tonelli Theorems, Convolutions
- Differentiation of measures (if time permits)

**Lecture notes**


**Literature**

1. Lecture notes by Professor Michael Struwe (http://www.math.ethz.ch/~struwe/Skripten/AnalysisIII-SS2007-18-4-08.pdf)
2. L. Evans and R.F. Gariepy "Measure theory and fine properties of functions"
3. Walter Rudin "Real and complex analysis"
4. R. Bartle The elements of Integration and Lebesgue Measure

**Prerequisites / notice**

Analysis 1 & 2 und basic notions of topology

### 401-3461-00L Functional Analysis I

**W 9 credits 4V+1U M. Burger**

**Abstract**

Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed graph theorem; spectral theory of self-adjoint operators in Hilbert spaces. Basics of Sobolev spaces.

**Objective**

Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.
Recommended references include the following:


Prerequisites / notice

Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH. Most importantly: fluency with point set topology and measure theory, in part. Lebesgue integration and $L^p$ spaces.

Competencies

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<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Problem-solving</td>
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401-3531-00L Differential Geometry I

At most one of the three course units (Bachelor Core Courses)

401-3461-00L Functional Analysis I

401-3531-00L Differential Geometry I

401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract

Introduction to differential manifolds and differential geometry.

Objective

Learn to compute, describe, prove, and solve problems in the language of differential geometry.

Content

Submanifolds of $\mathbb{R}^n$, immersions, submersions, and embeddings, Sard's Theorem, abstract differentiable manifolds, charts, vector fields and flows, vector bundles, tensor fields, covariant derivatives, parallel transport, Riemannian metrics, geodesics, Riemann curvature tensor. Complete manifolds, Hopf-Rinow theorem. Many examples including curves, surfaces, hyperbolic space, $S^3$, the unit quaternions, the Gauss-Bonnet theorem, etc.

Literature

John M. Lee: Introduction to Smooth Manifolds

This following books were inherited from before. The only one I know is DoCarmo.

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie. Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Competencies

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401-3601-00L Probability Theory

At most one of the three course units (Bachelor Core Courses)

401-3461-00L Functional Analysis I

401-3531-00L Differential Geometry I

401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

Abstract

Basics of probability theory and the theory of stochastic processes in discrete time.
The course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

Lecture notes will be available in electronic form.

Literature

- H. Bauer, *Probability Theory, de Gruyter 1996*

**Prerequisites / notice**

Prerequisites:
- Measure Theory
- Basic notions in probability theory (probability space, conditional probability, Borel Cantelli, Dynkin Lemma, random variables, expectation, variance, law of large numbers).

**Competencies**

<table>
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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>Creative Thinking</th>
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**Personal Competencies**

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<tr>
<th>Creative Thinking</th>
<th>assessed</th>
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**401-3628-14L Bayesian Statistics**

*Does not take place this semester.*

**Abstract**

Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayesian tests and model selection, empirical Bayes, Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods.

**Objective**

Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.

**Content**

Topics that we will discuss are:

- Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)

**Lecture notes**

A script will be available in English.

**Literature**


Additional references will be given in the course.

**Prerequisites / notice**

Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

**Competencies**

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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**Personal Competencies**

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<tr>
<th>Creative Thinking</th>
<th>assessed</th>
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**401-3621-00L Fundamentals of Mathematical Statistics**

**Abstract**

In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

**Objective**

The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.

**Content**

Topics to be covered include:

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

**Lecture notes**

See information on course homepage

**Prerequisites / notice**

Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants who do not have a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitstheorie").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.
Objective

After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

Content

The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Lecture notes/Will be provided on Moodle

Literature

A list of relevant literature is available on Moodle

Prerequisites / notice

High-school mathematics and physics knowledge required.

Competencies

<table>
<thead>
<tr>
<th>401-6215-00L</th>
<th>Using R for Data Analysis and Graphics (Part I)</th>
<th>W</th>
<th>1.5 credits</th>
<th>1G</th>
<th>A. Hauser</th>
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<tbody>
<tr>
<td>Competencies</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Self-presentation and Social Influence</td>
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<td>Integrity and Work Ethics</td>
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</table>

401-6217-00L Using R for Data Analysis and Graphics (Part II)

Objective

The students will be able to use the software R efficiently for data analysis, graphics and simple programming.

Note: This part builds on "Using R... (Part I)", but can be taken independently from Part I.

Abstract

The course provides the second part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

Method-specific Competencies

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Subject-specific Competencies</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Types of data: numeric, character, logical and categorical data, missing values;</td>
<td>- What is R?</td>
<td>An Introduction to R. <a href="http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf">http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf</a></td>
</tr>
<tr>
<td>- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;</td>
<td>- R Basics: reading and writing data from/to files, creating vectors &amp; matrices, selecting elements of dataframes, vectors and matrices, arithmetics;</td>
<td>The course resources will be provided via the Moodle web learning platform.</td>
</tr>
<tr>
<td>- Writing simple functions;</td>
<td>- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.</td>
<td>Subscribing via Mystudies &quot;automatically&quot; makes you a student participant of the Moodle course of this lecture, which is at</td>
</tr>
<tr>
<td>- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.</td>
<td></td>
<td><a href="https://moodle-app2.let.ethz.ch/course/view.php?id=20847">https://moodle-app2.let.ethz.ch/course/view.php?id=20847</a></td>
</tr>
</tbody>
</table>

Content

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

Lecture notes

Increasing importance of computer software in research. Introduction to the software R for scientists. An introduction to RStudio. What is R?

Prerequisites / notice

https://moodle-app2.let.ethz.ch/course/view.php?id=20847
The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options
- Extending basic R: packages

The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary
Adaptability and Flexibility

The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical
analysis.

For the lectures the main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis.

ARMA, ARIMA, Introduction into GARCH models
Forecasting
Spectral analysis, spectral densities
Elimination of seasonality
Trend estimation
Autocorrelation
Stationarity

The key topics which will be covered as:

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org


Basic knowledge of R equivalent to "Using R .. (part 1)" (= 401-6215-00L ) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform.
As from FS 2019, subscribing via Mystudies should *automatically* make you a student participant of the Moodle course of this lecture, which is at
https://moodle-app2.let.ethz.ch/course/view.php?id=20848

<table>
<thead>
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<td>Techniques and Technologies</td>
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<table>
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<td>Basic knowledge of R equivalent to &quot;Using R .. (part 1)&quot; (= 401-6215-00L ) is a prerequisite for this course.</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<table>
<thead>
<tr>
<th>Competencies</th>
<th>401-4623-00L</th>
<th>Time Series Analysis</th>
<th>W</th>
<th>4 credits</th>
<th>2G</th>
<th>F. Balabdaoui</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.</td>
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<tr>
<td>Objective</td>
<td>The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.</td>
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<tr>
<td>Content</td>
<td>This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.</td>
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</table>

| Literature | The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis |

<table>
<thead>
<tr>
<th>Competencies</th>
<th>401-0625-01L</th>
<th>Applied Analysis of Variance and Experimental Design</th>
<th>W</th>
<th>5 credits</th>
<th>2V+1U</th>
<th>L. Meier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<tr>
<td>Content</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<th>Competencies</th>
<th>401-0647-00L</th>
<th>Introduction to Mathematical Optimization</th>
<th>W</th>
<th>5 credits</th>
<th>2V+1U</th>
<th>D. Adjiashvili</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering. The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.</td>
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<td>Objective</td>
<td>Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering. The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.</td>
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<td>Decision-making</td>
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<td>Self-direction and Self-management</td>
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</table>
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

In the course “Atmospheric Physics”, the competencies of process understanding, system understanding and data analysis & interpretation are fostered. The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

A script will be available.

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, especially prediction of showers and severe convective storms, and optical phenomena.

In the course “Atmospheric Physics”, the competencies of process understanding, system understanding and data analysis & interpretation are taught, acquired and examined. Measurement methods are taught as well.

The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=22731
Prerequisites / notice

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

Competencies

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Practical Courses

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<tr>
<th>Number</th>
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<th>Type</th>
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<tbody>
<tr>
<td>402-0000-01L</td>
<td>Physics Lab 1</td>
<td>O</td>
<td>5 credits</td>
<td>4P</td>
<td>A. Eichler, M. Kroner, A. Eggenberger</td>
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<tr>
<td></td>
<td>Please make an enrolment in mystudies.</td>
<td>For further information visit: <a href="https://ap.phys.ethz.ch">https://ap.phys.ethz.ch</a></td>
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<tr>
<td></td>
<td>Only students from 3rd Semester BSc Physics and IN are admitted to Physics Lab 2.</td>
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</table>

Abstract

Introductory lab course in experimental physics

Objective

The overarching topic of the student lab is an understanding of the fundamental challenges in experimental physics. The following aspects are particularly important:

- Why does one conduct experiments, and how should an experiment be planned?
- How does one set up an experiment? What are the important characteristics of measurement instruments and methods?
- Introduction to basic statistical data analysis
- Critical interpretation of measurement results
- Scientific communication, reporting, graphic representation of results
- Ethical aspects of experimental research and reporting

Content

Experiments with examples from mechanics, optics, thermodynamics, electronics, electricity and nuclear physics.

Lecture notes

Manual for the experiments; collection of supplementary material.

Prerequisites / notice

6 Experiments have to be conducted (typically in teams of 2).

In the first week, only an introductory event is taking place in the lecture hall. This event provides relevant information regarding safety and organisational matters (e.g. testat conditions).

Students must pass an online safety test to be allowed to conduct experiments in the lab. It is recommended that every student acquires an individually adjusted safety goggle.

Competencies

<table>
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<th>Subject-specific Competencies</th>
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402-0000-09L Physics Lab 3

Abstract

This laboratory course provides basic training of experimental skills. These are experimental design, implementation, measurement, data analysis and interpretation, as well as error analysis. The experimental work has to be complemented by a concise written report, which trains the scientific writing skills.

Manuals for the individual experiments are available in English.

Objective

Students learn to independently perform advanced experiments and document them scientifically correct.

Students are required to attend a safety lecture on the first day of the course and pass the corresponding online moodle-test before being allowed to access the laboratory rooms and perform the experiments.

The following aspects are emphasized:

- understanding complicated physical phenomena
- structured approach to experiments with complex instruments
- various practical aspects of experimenting and determining uncertainties
- learning the relevant statistical methods for data analysis
- interpretation of measurements and uncertainties
- describing the experiments and the results in a scientifically proper manner, in direct analogy to publishing
- ethical aspects of experimental research and scientific communication

Content

We offer experiments covering the following topics:

Basic topics from mechanics, optics, thermodynamics, electromagnetism and electronics; as well as central topics from nuclear and particle physics, quantum electronics, quantum mechanics, solid state physics and astrophysics.

Lecture notes

Instructions for experiments are available in English.

Prerequisites / notice

From a variety of over 50 experiments, students have to perform 4 experiments covering different topics. The experimental work is complemented by writing a scientific report.

If a student intends to perform a semester exchange abroad, then experimental activities must be discussed with lecturers of Physics Lab 3 before beginning of the semester, and in any case before leaving.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed


text

Method-specific Competencies

Analytical Competencies assessed
Problem-solving assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed


text

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed


text

Integrity and Work Ethics assessed
Critical Thinking assessed

Self-direction and Self-management assessed

Proseminars, Experimental and Theoretical Semester Papers

Detailed information at:
https://www.phys.ethz.ch/studies/bachelor/semester-projects.html

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
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<tr>
<td>402-0000-10L</td>
<td>Physics Lab 4</td>
<td>W</td>
<td>8</td>
<td>15P</td>
<td>M. Donegà, S. Gvasaliya</td>
</tr>
</tbody>
</table>

Prerequisite: "Physics Lab 3" completed. Before enrolling in "Physics Lab 4", please enrol in "Physics Lab 3".

Enrol at most once in the course of the Bachelor programme!

Abstract
This laboratory course provides basic training of experimental skills. These are experimental design, implementation, measurement, data analysis and interpretation, as well as error analysis. The experimental work has to be complemented by a concise written report, which trains the scientific writing skills.

Manuals for the individual experiments are available in English.

Objective
Students learn to independently perform advanced experiments and document them scientifically correct.

Students are required to attend a safety lecture on the first day of the course and pass the corresponding online moodle-test before being allowed to access the laboratory rooms and perform the experiments.

The following aspects are emphasized:
- understanding complicated physical phenomena
- structured approach to experiments with complex instruments
- various practical aspects of experimenting and determining uncertainties
- learning the relevant statistical methods for data analysis
- interpretation of measurements and uncertainties
- describing the experiments and the results in a scientifically proper manner, in direct analogy to publishing
- ethical aspects of experimental research and scientific communication

Content
We offer experiments covering the following topics:
Basic topics from mechanics, optics, thermodynamics, electromagnetism and electronics; as well as central topics from nuclear and particle physics, quantum electronics, quantum mechanics, solid state physics and astrophysics.

Lecture notes
Instructions for experiments are available in English.

Prerequisites / notice
From a variety of over 50 experiments, students have to perform 4 experiments covering different topics. The experimental work is complemented by writing a scientific report.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed

Critical Thinking assessed
Integrity and Work Ethics assessed
Self-direction and Self-management assessed

402-0218-BSL Research Project W 8 credits 15A Supervisors

Abstract
Students conduct a small research project within a research group or carry out a guided self-study of original papers on a given theoretical topic. The results are submitted in a written report and an oral presentation.

Objective
Students are enabled to:
- expand their knowledge in a specific area of physics,
- conduct a project (a) in a research laboratory or (b) on a specific topic of theoretical physics,
- discuss their project results and conclusions in a team,
- present their findings in written and oral form.
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: fostered
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Research Project II

402-0219-BSL

Abstract
Students conduct a small research project within a research group or carry out a guided self-study of original papers on a given theoretical topic. The results are submitted in a written report and an oral presentation.

Objective
Students are enabled to:
- expand their knowledge in a specific area of physics,
- conduct a project (a) in a research laboratory or (b) on a specific topic of theoretical physics,
- discuss their project results and conclusions in a team,
- present their findings in written and oral form.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: fostered
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-PHYS

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Additional Courses, Seminars and Colloquia

First or Second Year Additional Courses

Number  Title  Type  ECTS  Hours  Lecturers
402-0351-00L  Astronomy  Z  2 credits  2V  A. M. Glauser

Abstract
An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology

Objective
This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.

Content
Planeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie.

Literature
Der Neue Kosmos. A. Unsöld, B. Baschek, Springer
Oder sonstige Grundlehrbücher zur Astronomie.

Additional Courses (from Second Year Mathematics Bachelor)

Number  Title  Type  ECTS  Hours  Lecturers
401-2003-00L  Algebra I  Z  7 credits  3V+2U  L. Halbeisen

Abstract
Introduction and development of some basic algebraic structures - groups, rings, fields.
Objective
Introduction to basic notions and results of group, ring and field theory.

Content
Group Theory: basic notions and examples of groups, subgroups, factor groups, homomorphisms, group actions, Sylow theorems, applications

Ring Theory: basic notions and examples of rings, ring homomorphisms, ideals

Field Theory: basic notions and examples of fields and field extensions, applications

Literature
J.F. Humphreys: A Course in Group Theory (Oxford University Press)
G. Smith and O. Tabachnikova: Topics in Group Theory (Springer-Verlag)

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Critical Thinking

Personal Competencies
- Creative Thinking
- Fostering

Seminars and Colloquia

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
402-0101-00L | The Zurich Physics Colloquium | E- | 0 credits | 1K | S. Huber, A. Refregier, University lecturers
402-0800-00L | The Zurich Theoretical Physics Colloquium | E- | 0 credits | 1K | J. Renes, University lecturers
401-5330-00L | Talks in Mathematical Physics | E- | 0 credits | 1K | M. Gaberdiel, G. M. Graf, P. Hintz, T. Willwacher
402-0551-00L | Laser Seminar | E- | 0 credits | 1S | T. Esslinger, J. Faist, J. Home, A. Imamoglu, F. Merkt, H. J. Wörner
402-0600-00L | Nuclear and Particle Physics with Applications | E- | 0 credits | 2S | A. Rubbia, K. S. Kirch, R. Wallny
402-0893-00L | Particle Physics Seminar | E- | 0 credits | 1S | T. K. Gehrmann
402-0700-00L | Seminar in Elementary Particle Physics | E- | 0 credits | 1S | M. Spira
402-0746-00L | Seminar: Particle and Astrophysics (Aktuelles aus der Teilchen- und Astrophysik) | E- | 0 credits | 1S | University lecturers
402-0300-00L | IPA Colloquium | E- | 0 credits | 1S | A. Biland, A. de Costa, A. Refregier, further lecturers
402-0530-00L | Mesoscopic Systems | E- | 0 credits | 1S | T. M. Ihn
227-0980-00L | Seminar on Biomedical Magnetic Resonance | E- | 0 credits | 1S | K. P. Prüssmann, S. Kozerke, M. Weiger Senften
227-1043-00L | Neuroinformatics - Colloquia (University of Zurich) | E- | 0 credits | 1K | S.-C. Liu, R. Hahnloser, V. Mante

Mind the enrolment deadlines at UZH:

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2035 of 2667
Abstract
The colloquium in Neuroinformatics is a series of lectures given by invited experts. The lecture topics reflect the current themes in neurobiology and neuromorphic engineering that are relevant for our Institute.

Objective
The goal of these talks is to provide insight into recent research results. The talks are not meant for the general public, but really aimed at specialists in the field.

Content
The topics depend heavily on the invited speakers, and thus change from week to week. All topics concern neural computation and their implementation in biological or artificial systems.

402-0396-00L Recent Research Highlights in Astrophysics (University of Zurich)

E- 0 credits 1S
University lecturers

Abstract
Research colloquium

▲ Selection of Higher Semester Courses

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>401-2813-00L</td>
<td>Programming Techniques for Scientific Simulations I</td>
<td>W</td>
<td>5 credits</td>
<td>4G</td>
<td>R. Käppeli</td>
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<td>Students in the Master's Degree Programme in Computational Science and Engineering must enrol only if this course unit is an additional requirement.</td>
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Abstract
This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.

Objective
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

402-0713-00L Astro-Particle Physics I

W 6 credits 2V+1U A. Biland

Abstract
This lecture gives an overview of the present research in the field of Astro-Particle Physics, including the different experimental techniques. In the first semester, main topics are the charged cosmic rays including the antimatter problem. The second semester focuses on the neutral components of the cosmic rays as well as on some aspects of Dark Matter.

Objective
Successful students know:
- experimental methods to measure cosmic ray particles over full energy range
- current knowledge about the composition of cosmic ray
- possible cosmic acceleration mechanisms
- correlation between astronomical object classes and cosmic accelerators
- information about our galaxy and cosmology gained from observations of cosmic ray

Content
First semester (Astro-Particle Physics I):
- definition of 'Astro-Particle Physics'
- important historical experiments
- chemical composition of the cosmic rays
- direct observations of cosmic rays
- indirect observations of cosmic rays
- 'extended air showers' and 'cosmic muons'
- 'knee' and 'ankle' in the energy spectrum
- the 'anti-matter problem' and the Big Bang
- 'cosmic accelerators'

Lecture notes
See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/

Literature
See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Media and Digital Technologies fostered
- Problem-solving assessed

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

402-0737-00L Energy and Sustainability in the 21st Century (Part I)

W 6 credits 2V+1U P. Morf

Abstract
Part I of this course covers the energy-related topics in this two-semester course. The importance of energy to life and our modern culture is explored and placed in the perspective of the ongoing energy transition in the context of necessary and urgent decarbonization efforts.

Objective
Why is energy important for life, economy and our society?
- How did energy use change over time? Which effects did these changes have on the environment?
- What are the physical basics of energy technologies?
- When, why and how did technology and science of energy come together?
- What are the limits and benefits of all the various energy technologies?
- How can different energy technologies be compared?
- Can we understand the changes in the current energy systems?
- How will the energy systems of the future look like?
- How fast can we and should we enforce the current energy transition?
- Which could be the overall guide lines for a working and sustainable energy system of the future?
Content
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literature
The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
Clean Disruption of Energy and Transportation, T. Seba 2014
Energy and Civilization: A History, V. Smil, 2018

Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.

Competencies

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Prerequisites / notice
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

Elective (Physics Master)

402-0580-00L Superconductivity

Abstract

Objective
Introduction to the most important concepts of superconductivity both on phenomenological and microscopic level, including experimental and theoretical aspects.

Content
This lecture course provides an introduction to superconductivity, covering both experimental as well as theoretical aspects. The following topics are covered:
Basic phenomena of superconductivity: thermodynamics, electrodynamics, London and Pippard theory; Ginzburg-Landau theory: spontaneous symmetry breaking, flux quantization, properties of type I and II superconductors; mixed phase; microscopic BCS theory: electron-phonon mechanism, Cooper pairing, coherent state, quasiparticle spectrum, thermodynamics and response to magnetic fields; Josephson effect, superconducting quantum interference devices (SQUID) and other applications.

Lecture notes
Lecture notes and additional materials are available.

Literature
M. Tinkham "Introduction to Superconductivity"
P. G. de Gennes "Superconductivity Of Metals And Alloys"
A. A. Abrikosov "Fundamentals of the Theory of Metals"
J.B. Ketterson & S.N. Song "Superconductivity"
H. Stolz "Supraleitung" (German)
K. Fossheim & A. Sudbo "Superconductivity: Physics and Applications"

Prerequisites / notice
The preceding attendance of the scheduled lecture courses "Introduction to Solid State Physics" and "Quantum Mechanics I" are mandatory. The lectures "Quantum Mechanics II" and "Solid State Theory" provide the most optimal conditions to follow this course.

Elective (Physics Master)

402-0674-00L Physics in Medical Research: From Atoms to Cells

Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
Objective

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams on micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

| 227-1037-00L | Introduction to Neuroinformatics | W | 6 credits | 2V+1U+1A | V. Mante, B. Grewe, G. Indiveri, M. Payvand |

Abstract

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Objective

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

| 401-3531-00L | Differential Geometry I | W | 9 credits | 4V+1U | U. Lang |

At most one of the three course units (Bachelor Core Courses) 401-3461-00L Functional Analysis I 401-3531-00L Differential Geometry I 401-3801-00L Probability Theory can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract

Introduction to differential manifolds and differential geometry.

Objective

Learn to compute, describe, prove, and solve problems in the language of differential geometry.

Content

Submanifolds of R^n, immersions, submersions, and embeddings, Sard's Theorem, abstract differentiable manifolds, charts, vector fields and flows, vector bundles, tensor fields, covariant derivatives, parallel transport, Riemannian metrics, geodesics, Riemann curvature tensor. Complete manifolds, Hopf-Rinow theorem. Many examples including curves, surfaces, hyperbolic space, S^3, the unit quaternions, the Gausss-Bonnet theorem, etc.

Literature

John M. Lee: Introduction to Smooth Manifolds
John M. Lee: Introduction to Riemannian Manifolds

This following books were inherited from before. The only one I know is DoCarmo.

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie. Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds
### Competencies

<table>
<thead>
<tr>
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<th>Concepts and Theories</th>
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### 401-3461-00L Functional Analysis I

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<tr>
<td>401-3531-00L Differential Geometry I</td>
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<tr>
<td>401-3601-00L Probability Theory</td>
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</table>

**Abstract**

Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Haar-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed graph theorem; spectral theory of self-adjoint operators in Hilbert spaces. Basics of Sobolev spaces.

**Objective**

Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

**Literature**

Recommended references include the following:


**Prequisites / notice**

Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH. Most importantly: fluency with point set topology and measure theory, in part. Lebesgue integration and L^p spaces.

### Competencies

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### 401-3601-00L Probability Theory

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<tr>
<td>401-3601-00L Probability Theory</td>
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**Abstract**

Basics of probability theory and the theory of stochastic processes in discrete time

**Objective**

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- measure theory formalism and probability theory, Dynkin’s lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

**Content**

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- measure theory formalism and probability theory, Dynkin’s lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

**Lecture notes**

will be available in electronic form.

**Literature**

- H. Bauer, Probability Theory, de Gruyter 1996
- J. Jacod and P. Protter, Probability essentials, Springer 2004
- A. Klenke, Wahrscheinlichkeitsstheorie, Springer 2005
- D. Williams, Probability with martingales, Cambridge University Press 1991
<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
<th>Competencies</th>
<th>Notice</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subject-specific Competencies</td>
<td>assessed</td>
<td>- Measure Theory</td>
</tr>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td>- Basic notions in probability theory (probability space, conditional probability, Borel Cantelli, Dynkin Lemma, random variables, expectation, variance, law of large numbers).</td>
</tr>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal Competencies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

### Concepts and Theories

- Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, fostered

---

**Objective**

The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.

**Competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Problem-solving
- Personal Competencies: Creative Thinking

---

**Prerequisites / notice**

No prior knowledge in electronics is required.

---

<table>
<thead>
<tr>
<th>401-3621-00L</th>
<th>Fundamentals of Mathematical Statistics</th>
<th>W</th>
<th>9 credits</th>
<th>4V+1U</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.</td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

---

**Prerequisites / notice**

- no prior knowledge in electronics is required

---

<table>
<thead>
<tr>
<th>402-0247-00L</th>
<th>Electronics for Physicists I (Analogue)</th>
<th>W</th>
<th>6 credits</th>
<th>4V+2P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Prerequisites / notice**

- no prior knowledge in electronics is required

---

<table>
<thead>
<tr>
<th>402-0010-00L</th>
<th>Basics of Computing Environments for Scientists</th>
<th>Z</th>
<th>0 credits</th>
<th>1V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists. The &quot;IT and Information Security&quot; crash course will address the most common threats you'll encounter when using the internet and teach you how to fend them off. The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges. The &quot;Linux Basics&quot; modules offer an introduction to the Linux landscape and show how to work on the shell by using command line tools. The first part provides a basic understanding of Linux systems and their components. It introduces commands essential to working with local and remote machines. The second part focuses on more advanced tools and workflows and provides guidelines to scripting, automation and customization. The &quot;Python Ecosystem&quot; modules present various aspects of the environment around Python. Without teaching the Python programming language itself, it aims at providing understanding of various concepts surrounding it. The first part focuses on getting ready to run code. It discusses the management of Python interpreters, packages and virtual environments. The second part presents tools for writing Python code and interacting with strings. From development environments (IDE, Jupyter), over code formatters and linters, to string formatting and parsing with regular expressions. The third part sits at the interface between Python code and external data files. We explain how to read or write files, discuss data types and file formats. We show how to handle configuration parameters and mention tools to automate the data analysis. The &quot;System Aspects&quot; module deals with the hardware-related side of scientific computing. To get the best performance out of your scientific code, you have to be aware of the underlying hardware and adapt to it. Use the dedicated web page <a href="https://www.lehrbetrieb.ethz.ch/laborpraktika">https://www.lehrbetrieb.ethz.ch/laborpraktika</a> to register. Enrolled students are eligible for an attestation of attendance after visiting at least 3 out of the 5 modules. Refer to <a href="https://compenv.phys.ethz.ch">https://compenv.phys.ethz.ch</a> for the detailed contents.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists. The &quot;IT and Information Security&quot; crash course will address the most common threats you'll encounter when using the internet and teach you how to fend them off. The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges. The &quot;Linux Basics&quot; modules offer an introduction to the Linux landscape and show how to work on the shell by using command line tools. The first part provides a basic understanding of Linux systems and their components. It introduces commands essential to working with local and remote machines. The second part focuses on more advanced tools and workflows and provides guidelines to scripting, automation and customization. The &quot;Python Ecosystem&quot; modules present various aspects of the environment around Python. Without teaching the Python programming language itself, it aims at providing understanding of various concepts surrounding it. The first part focuses on getting ready to run code. It discusses the management of Python interpreters, packages and virtual environments. The second part presents tools for writing Python code and interacting with strings. From development environments (IDE, Jupyter), over code formatters and linters, to string formatting and parsing with regular expressions. The third part sits at the interface between Python code and external data files. We explain how to read or write files, discuss data types and file formats. We show how to handle configuration parameters and mention tools to automate the data analysis. The &quot;System Aspects&quot; module deals with the hardware-related side of scientific computing. To get the best performance out of your scientific code, you have to be aware of the underlying hardware and adapt to it. Use the dedicated web page <a href="https://www.lehrbetrieb.ethz.ch/laborpraktika">https://www.lehrbetrieb.ethz.ch/laborpraktika</a> to register. Enrolled students are eligible for an attestation of attendance after visiting at least 3 out of the 5 modules. Refer to <a href="https://compenv.phys.ethz.ch">https://compenv.phys.ethz.ch</a> for the detailed contents.</td>
<td></td>
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</tr>
</tbody>
</table>

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**Notice**

- No registration required via myStudies.

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**Course Information**

- **401-3621-00L**: Fundamentals of Mathematical Statistics
- **402-0247-00L**: Electronics for Physicists I (Analogue)
- **402-0010-00L**: Basics of Computing Environments for Scientists

---

**Enrollment**

- Fundamentals of Mathematical Statistics: W 9 credits
- Electronics for Physicists I (Analogue): W 4 credits
- Basics of Computing Environments for Scientists: Z 0 credits

---

**Credit Information**

- Fundamentals of Mathematical Statistics: 9 credits
- Electronics for Physicists I (Analogue): 4 credits
- Basics of Computing Environments for Scientists: 0 credits

---

**Instructor Information**

- J. Ziegel
- G. Bison
- W. E. Erdmann
- C. D. Herzog, C. Becker, S. Müller

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**Data**

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- Autumn Semester 2024
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**Content**

**Introduction:**
- IT at D-PHYS (IT service providers and IT services at D-PHYS)
- IT and Information Security

**Modules:**
- Linux Basics I (system components, basic shell usage)
- Linux Basics II (advanced tools, scripting)
- Python Ecosystem I (interpreters, packages, virtual environments)
- Python Ecosystem II (development environments, formatter and linter, string formatting, regexp)
- Python Ecosystem III (external data files, config parameters and automation)
- System Aspects (how the hardware affects your scientific code and vice versa)

**Competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Problem-solving</th>
</tr>
</thead>
<tbody>
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<td></td>
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**Physics Bachelor - Key for Type**

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
</tr>
</tbody>
</table>

**ECTS**

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
# Educational Science

General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>0</td>
<td>2V</td>
<td>E. Stern, M. Rau</td>
</tr>
</tbody>
</table>

**Abstract**

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

- Thematic Schwerpunkte:
  - Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen


**Lecture notes**

Folien werden zur Verfügung gestellt.

**Literature**


**Prerequisites / notice**

This lecture is only apt for students who intend to enrol in the programs "Lehrplomdi" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

<table>
<thead>
<tr>
<th>Number</th>
<th>Coping with Psychosocial Demands of Teaching (EW4 W DZ)</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W DZ)</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>S. Maurer, P. Caprez, I. Sargenti</td>
</tr>
</tbody>
</table>

**Abstract**

In this class, students will learn concepts and skills for coping with psychosocial demands of teaching

**Objective**

1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).

<table>
<thead>
<tr>
<th>Number</th>
<th>Cognitively Activating Instructions in MINT Subjects ■ W</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects ■ W</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
</tbody>
</table>

**Abstract**

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)"

**Objective**

- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

**Prerequisites / notice**

Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

<table>
<thead>
<tr>
<th>Number</th>
<th>Human Intelligence</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)"

**Objective**

- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

<table>
<thead>
<tr>
<th>Number</th>
<th>Formation of Knowledge in STEM Fields in Primary and Secondary School ■</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School ■</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Markwalder</td>
</tr>
</tbody>
</table>
Diploma Sport).
This course unit can only be enroled after successful participation in the course 871-0240-00L "Human Learning (EW 1)".

Abstract
Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar (ca. 16 h), 2) collaboration with elementary school teacher in a class (ca. 34 h, with approx. 50% spent in the elementary or middle school class and ca. 50% for preparation), and 3) final report (ca. 10 h). Registration implies participation in all 3 parts.

Objective
Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing Children, language problems etc.).

Content
Students learn more about the potential and challenges of pupils. They get to know the early stages of knowledge as well as the development of pre-concepts of students in their subject area. The seminar with a phase of cooperation consists of three phases: In the block seminar, pre-concepts are discussed in their own subject as well as theoretical inputs from developmental and cognitive psychology. During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students' level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

Prerequisites / notice
https://www.minterlink.ch/student

Number Title Type ECTS Hours Lecturers
402-0910-00L Physics Didactics I: Special Didactics of Physics Teaching ■ O 4 credits 3G M. Mohr

Further information is available from the lecturer via email: mamohr@ethz.ch

Simultaneous enrolment in Introductory Internship Physics - course 402-0920-00L - is compulsory for Teaching Diploma Physic

Objective
Die Studierenden verfügen über fachdidaktisches Grundwissen für den Physikunterricht an einer Mittelschule. Sie können eigene Lektionen unter Berücksichtigung der vielfältigen Rahmenbedingungen planen, durchführen und evaluieren. Sie reflektieren ihren Unterricht und sind bestrebt, ihn didaktisch und pädagogisch weiter zu entwickeln.

Die Studierenden kennen die Einsatzmöglichkeiten, Chancen und Schwierigkeiten verschiedener Unterrichtsmethoden und Hilfsmittel. Sie können die Eignung von Unterrichtsformen im Hinblick auf eine Lernsituation beurteilen. Sie bemühen sich in ihrem Unterricht, geeignete Methoden und Medien angepasst an die Klasse und das Thema einzusetzen.


Content

Lecture notes
Folien und weitere Unterlagen werden zur Verfügung gestellt

Literature

Prequisites / notice
Die Veranstaltung ist zusammen mit dem Einführungspraktikum zu belegen

402-0915-00L Teaching Internship Including Examination Lessons Teaching Internship Physics for TC, Repetition of the Teaching Internship is excluded even if Examination Lessons are to be repeated.

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

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**Lecture notes**

Dokument: schriftliche Vorbereitung für Prüfungslektionen.

**Literatur**

Wird von der Praktikumslehrperson bestimmt.

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### 402-0917-00L Mentored Work Subject Didactics Physics A

**Title:** Mentored Work Subject Didactics in Physics for TC and Teaching Diploma.

**Objective**

1. Die Studierenden sammeln Erfahrungen in der Unterrichtsführung, der Auseinandersetzung mit Lernenden, der Klassenbetreuung und der Leistungsbeurteilung.
2. Zu Beginn des Praktikums plant die Praktikumslehrperson gemeinsam mit dem/der Studierenden das Praktikum und die Arbeitsaufträge.
3. Die schriftlich dokumentierten Ergebnisse der Arbeitsaufträge sind Bestandteil des Portfolios der Studierenden.
4. Anlässlich der Hospitationen erläutert die Praktikumslehrperson ihre fachlichen, fachdidaktischen und pädagogischen Überlegungen, auf deren Basis sie den Unterricht geplant hat und tauscht sich mit dem/der Studierenden aus.

**Content**

- Themen für die beiden Prüfungslektionen am Schluss des Praktikums erfahren die Studierenden in der Regel eine Woche vor dem Prüfungstermin.
- Sie erstellen eine Vorbereitung gemäß Anleitung und reichen sie bis am Vortrag um 12 Uhr den beiden Prüfungsexperten (Fachdidaktiker/-in, Departementsvertreter/-in) ein. Die gehaltenen Lektionen werden kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltenen Lektionen im Rahmen eines kurzen Kolloquiums.

**Lecture notes**

http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

**Prerequisites / notice**

- The mentored work should usually be finished before the teaching internship. FD2 (402-0909-00L) is required or should be achieved in the same semester.

**Competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Problem-solving, Project Management
- Personal Competencies: Adaptability and Flexibility, Creative Thinking, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

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### Specialized Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Morf</td>
</tr>
</tbody>
</table>

**Abstract**

Part I of this course covers the energy-related topics in this two-semester course. The importance of energy to life and our modern culture is explored and placed in the perspective of the ongoing energy transition in the context of necessary and urgent decarbonization efforts. How much energy do we need and how can it be provided in a way that enables a sustainable existence?

**Objective**

1. Why is energy important for life, economy and our society?
2. How did energy use change over time? Which effects did these changes have on the environment?
3. What are the physical basics of energy technologies?
4. When, why and how did technology and science of energy come together?
5. What are the limits and benefits of all the various energy technologies?
6. How can different energy technologies be compared?
7. Can we understand the changes in the current energy systems?
8. How will the energy systems of the future look like?
9. How fast can we and should we enforce the current energy transition?
10. Which could be the overall guide lines for a working and sustainable energy system of the future?
Content
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Life Cycle Assessment of Energy Technologies – problems and possibilities
13. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literature
The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
Clean Disruption of Energy and Transportation, T. Seba 2014

Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
Practice in the explanation of complex topics in physics as the core competence of the teaching profession. Improvement of the physics education by providing attractive recent topics with regard to future curricular decisions and the public view of physics.

Content
Choice of topic by individual arrangement

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

Abstract
Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology

Objective
The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.
Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and fieldeffect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC's and DAC's, introduction in CMOS technology. Practical exercises in small groups to the above themes complement the lectures.

Prerequisites / notice
no prior knowledge in electronics is required

## Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>fostered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>Problem-solving</td>
<td>fostered</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>fostered</td>
</tr>
</tbody>
</table>

## Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
</tbody>
</table>

## Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
</tbody>
</table>

## ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Electrical Engineering (MINT) Science Teaching Diploma

Please note that the course number will change from HS24 onwards. This change will have no effect on the courses and performances already completed and will be recognised for the respective degree.

Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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<td></td>
<td>Objective</td>
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</tr>
<tr>
<td></td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<tr>
<td></td>
<td>- Get information about recent literature on learning and instruction</td>
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<td></td>
<td>Prerequisites / notice</td>
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<tr>
<td></td>
<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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<tr>
<td>871-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>- Understanding of research methods used in the empirical human sciences</td>
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<td></td>
<td>- Getting to know intelligence tests</td>
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<td></td>
<td>- Understanding findings relevant for education</td>
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<tr>
<td></td>
<td>see Educational Science Teaching Diploma</td>
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</table>

Subject Didactics in Physics

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0910-00L</td>
<td>Physics Didactics I: Special Didactics of Physics Teaching</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>M. Mohr</td>
</tr>
<tr>
<td></td>
<td>Limited number of participants.</td>
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<tr>
<td></td>
<td>Further information is available from the lecturer via email:</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td><a href="mailto:mamohr@ethz.ch">mamohr@ethz.ch</a></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Simultaneous enrolment in Introductory Internship Physics</td>
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<tr>
<td></td>
<td>- course 402-0920-00L - is compulsory for Teaching Diploma Physic</td>
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<td>Objective</td>
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<tr>
<td></td>
<td>Die Studierenden verfügen über fachdidaktisches Grundwissen für den Physikunterricht an einer Mittelschule. Sie können eigene Lektionen unter Berücksichtigung der vielfältigen Rahmenbedingungen planen, durchführen und evaluieren. Sie reflektieren ihren Unterricht und sind bestrebt, ihn didaktisch und pädagogisch weiter zu entwickeln.</td>
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<td></td>
<td>Die Studierenden kennen die Einsatzmöglichkeiten, Chancen und Schwierigkeiten verschiedener Unterrichtsmethoden und Hilfsmittel. Sie können die Eignung von Unterrichtsformen im Hinblick auf eine Lernsituation beurteilen. Sie bemühen sich in ihrem Unterricht, geeignete Methoden und Medien angepasst an die Klasse und das Thema einzusetzen.</td>
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<tr>
<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Themenorientierte Schwerpunkte</td>
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<tr>
<td></td>
<td>Fachspezifisches: Sachstruktur der gängigen Unterrichtsthemen, Alltagsbezüge, Fehlvorstellungen, Demonstrations- und Schülerexperimente, Arbeitsmittel zu physikalischen Themen des Grundlagen- und Schwerpunkttunterrichts</td>
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<tr>
<td></td>
<td>Einsatz verschiedener Unterrichtsmaterialien: Experimente, Computer, Taschenrechner, Video, Simulation Unterrichtsformen: Lernaufgabe, Werkstatt, Puzzle, Projekt, Gruppenarbeit, Praktikum Lernformen</td>
<td></td>
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<tr>
<td></td>
<td>Interaktive Lehr-Lernveranstaltung mit Vorträgen und Demonstrationen des Dozenten, studentischer Einzel- und Kleingruppenarbeit, kurzen Präsentationen der Studierenden, Verifizierung der Inhalte durch Bearbeitung von Aufträgen unter der Kontrolle der Dozenten</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<tr>
<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>Folien und weitere Unterlagen werden zur Verfügung gestellt</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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</tr>
<tr>
<td></td>
<td>Die Veranstaltung wird mitgeteilt mit D. Kühler</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0917-00L</td>
<td>Mentored Work Subject Didactics Physics A</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>G. Schiltz, A. Vaterlaus</td>
</tr>
<tr>
<td></td>
<td>Mentored Work Subject Didactics in Physics for TC and Teaching Diploma.</td>
<td></td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.</td>
<td></td>
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<td></td>
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</tbody>
</table>
Objective
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content
Thematic Focus
The topics of the mentored work are mostly chosen from the high school curriculum.

Methods
With the help of the mentor the students individually work on a topic and write a thesis about it.

Lecture notes
http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

Prerequisites / notice
The mentored work should usually be finished before the teaching internship. FD2 (402-0909-00L) is required or should be achieved in the same semester.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

402-0918-00L
Mentored Work Subject Didactics Physics B
Mentored Work Subject Didactics in Physics for TC and Teaching Diploma.

Abstract
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

Objective
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content
Focus of conten
The topics of the mentored work are mostly chosen from the high school curriculum.

Methods
With the help of the mentor the students individually work on a topic and write a thesis about it.

Lecture notes
http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

Prerequisites / notice
The mentored work should usually be finished before the teaching internship. FD2 (402-0909-00L) is required or should be achieved in the same semester.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Professional Training in Physics
Simultaneous enrolment in Physics Didactics: Special Didactics of Physics Teaching - course 402-0910-00L - is compulsory.

Abstract
During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.

Objective
Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for teaching and the implementation of teaching. This early confrontation with the complexity of everything that teaching involves helps students decide whether they wish to, and, indeed, ought to, continue with the training. It forms a basis for the subsequent pedagogical and subject-didactics training.

Content

Literature
Wird von der Praktikumslehrperson bestimmt.

402-0911-00L Teaching Internship Physics

Abstract
The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and - impart these to their pupils.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Literature
Wird von der Praktikumslehrperson bestimmt.

402-0913-00L Teaching Internship Physics II

Abstract
This is a supplement to the Teaching Internship required to obtain a Master of Advanced Studies in Secondary and Higher Education in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.

Objective
Die Studierenden können die Bedeutung von Unterrichtsthemen in ihrem Fach unter verschiedenen Blickwinkeln einschätzen. Sie kennen und beherrschen das unterrichtliche Handwerk. Sie können ein gegebenes Unterrichtsthema für eine Gruppe von Lernenden fachlich und didaktisch korrekt strukturieren und in eine adäquate Lernumgebung umsetzen. Es gelingt ihnen, die Balance zwischen Anleitung und Offenheit zu finden, sodass die Lernenden sowohl übers nötige Freiraum wie über ausreichend Orientierung verfügen, um aktiv und effektiv flexibel nutzbare (Fach-)Wissen zu erwerben.

Content

Literature
Wird von der Praktikumslehrperson bestimmt.

402-0921-00L Examination Lesson II Physics

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Objective
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.
- They learn to assess pupils' work.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Core courses that counted towards the Bachelor or Master programme in physics or comprised additional admission requirements in subject didactics are not eligible for the teaching diploma.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0351-00L</td>
<td>Astronomy</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>A. M. Glauser</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Planeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<td></td>
<td>Kopien der Präsentationen werden zur Verfügung gestellt.</td>
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<tr>
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<td>Literature</td>
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<tr>
<td></td>
<td>Der Neue Kosmos. A. Unsöld, B. Baschek, Springer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oder sonstige Grundlehrbücher zur Astronomie</td>
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<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>P. Morf</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Part I of this course covers the energy-related topics in this two-semester course. The importance of energy to life and our modern culture is explored and placed in the perspective of the ongoing energy transition in the context of necessary and urgent decarbonization efforts.</td>
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<td>Objective</td>
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<td>Why is energy important for life, economy and our society?</td>
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<td>How did energy use change over time? Which effects did these changes have on the environment?</td>
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<td>What are the physical basics of energy technologies?</td>
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<td>When, why and how did technology and science of energy come together?</td>
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<td>What are the limits and benefits of all the various energy technologies?</td>
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<td>How can different energy technologies be compared?</td>
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<td>Can we understand the changes in the current energy systems?</td>
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<td>How will the energy systems of the future look like?</td>
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<td>How fast can we and should we enforce the current energy transition?</td>
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<td>Which could be the overall guide lines for a working and sustainable energy system of the future?</td>
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<td>Content</td>
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<td>1. Introduction to Energy – what is it all about</td>
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<td>2. Energy and making use of it – a short history of energy use and an overview on energy technologies</td>
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<td>3. Coal, oil and natural gas – fossil fuels</td>
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<td>4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts</td>
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<td>5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change</td>
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<td>6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology</td>
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<td>7. Breeding and Nuclear Fusion – can it work at all?</td>
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<td>8. Energy Storage – the need to increase capacity and for new technologies</td>
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<td>9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?</td>
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<td>11. Energy Systems – how everything can play together</td>
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<td>12. Life Cycle Assessment of Energy Technologies – problems and possibilities</td>
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<td>13. Economics of Energy, Learning Curves, Technology Assessments and Innovation</td>
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<td>14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?</td>
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<td></td>
<td>The Physics of Energy, R.L. Jaffe, W. Taylor, 2018</td>
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<td>Clean Disruption of Energy and Transportation, T. Seba 2014</td>
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<td>Energy and Civilization: A History, V. Smil, 2018</td>
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<td>Prerequisites / notice</td>
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<td>Basics of Physics applied to Energy and Energy Technology.</td>
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<td>Investigation on current problems (and possible solutions)</td>
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<td>related to the energy system and the environmental interactions.</td>
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<td>Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
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<td>Communication</td>
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<td>Creative Thinking</td>
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<td>Self-awareness and Self-reflection</td>
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<tr>
<td>402-0922-00L</td>
<td>Mentored Work Specialised Courses in Physics with</td>
<td>W</td>
<td>2 credits</td>
<td>4A</td>
<td>G. Schlitz, A. Vaterlaus</td>
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<td>Objective</td>
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<td>On the basis of a specified topic, the candidate shows that they are in a position to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle</td>
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<td>- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.</td>
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an Educational Focus A
Mentored Work Specialised Courses in the Respective Subject with an Educational Focus in Physics for TC and Teaching Diploma.

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
Practice in the explanation of complex topics in physics as the core competence of the teaching profession

Content
Choice of topic by individual arrangement

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed
- Negotiation assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

402-0923-00L Mentored Work Specialised Courses in Physics with an Educational Focus B

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
Improvement of the physics education by providing attractive recent topics with regard to future curricular decisions and the public view of physics

Content
Choice of topic by individual arrangement

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed
- Negotiation assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

402-0924-00L Internship Physics Didactics

Abstract
During the Internship Physics Didactics students teach 8 lessons in the classes of an internship teaching person. Students develop, test and analyze teaching arrangement under the guidance of a mentor (one of the lecturers).

Objective
Basic knowledge for the design of teaching arrangements is the topic of the Physics Didactics I and II courses. In the subsequent Internship Physics Didactics students combine the theoretical knowledge acquired in the didactics courses with practical aspects of teaching. During the internship students learn to transform their teaching goals into a real live class room setting considering subject specific, didactical and pedagogical aspects.

Content

Lecture notes
Wird vom Mentor bestimmt.
Das Fachdidaktikpraktikum kann erst nach dem Besuch der FD1 und frühestens mit der FD2 durchgeführt werden (eine gleichzeitige Belegung von Fachdidaktik 2 und Fachdidaktikpraktikum ist möglich).

**Prerequisites / notice**

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: fostered
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Literature**

- Astrophysics for physicist, Arnab Ray Choudhuri

**Abstract**

This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.

**Objective**

The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

**Method-specific Competencies**

- Analytical Competencies: fostered
- Decision-making: assessed
- Problem-solving: assessed

**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Literature**

- C. Kittel, Festkörperphysik
- Ashcroft & Mermin, Festkörperphysik

**Prerequisites / notice**

Voraussetzungen: Physik I, II, III wünschenswert

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

**Method-specific Competencies**

- Analytical Competencies: fostered
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Literature**

The script will be available on moodle.

**Prerequisites / notice**

Voraussetzungen: Physik I, II, III wünschenswert

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

**Method-specific Competencies**

- Analytical Competencies: fostered
- Decision-making: assessed
- Problem-solving: assessed

**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed
- Sensitivity to Diversity: assessed
- Negotiation: fostered

**Literature**

- Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors. basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology
- Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC's and DAC's, introduction in CMOS technology

**Prerequisites / notice**

no prior knowledge in electronics is required
### Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
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<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Morf</td>
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**Abstract**

Part I of this course covers the energy-related topics in this two-semester course. The importance of energy to life and our modern culture is explored and placed in the perspective of the ongoing energy transition in the context of necessary and urgent decarbonization efforts. How much energy do we need and how can it be provided in a way that enables a sustainable existence?

**Objective**

- Why is energy important for life, economy and our society?
- How did energy use change over time? Which effects did these changes have on the environment?
- What are the physical basics of energy technologies?
- When, why and how did technology and science of energy come together?
- What are the limits and benefits of all the various energy technologies?
- How can different energy technologies be compared?
- Can we understand the changes in the current energy systems?
- How will the energy systems of the future look like?
- How fast can we and should we enforce the current energy transition?
- Which could be the overall guidelines for a working and sustainable energy system of the future?

**Content**

1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

**Literature**

- The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
- Clean Disruption of Energy and Transportation, T. Seba 2014
- Energy and Civilization: A History, V. Smil, 2018

**Prerequisites / notice**

Basics of Physics applied to Energy and Energy Technology. Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
Objective
The general goal of the course consists in presenting ways to teach fundamentals of computer science, which are closely related to contents and methods of mathematics. After attending the course unit, a mathematics teacher is able to teach selected fundamentals of computer science in mathematics classes.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

Content
The main topics of the course unit "Computer Science in Secondary School Mathematics" represent a scientific and didactic added value for mathematics classes.

The course covers the didactics of logic, of cryptography, of finite state automata, of computability and of the introduction to programming. The students develop the understanding of fundamental scientific concepts such as algorithm, program, complexity, determinism, computation, automata, verification, testing, security of a cryptosystem and secure communication. They reflect on ways to embed them into a scientifically sound and didactically sustainable mathematics course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Lecture notes
Lituratur wird angegeben. Zusätzliche Unterlagen und Folien werden zur Verfügung gestellt.

Literatur

402-0247-00L Electronics for Physicists I (Analogue) W 4 credits 2V+2P G. Bison, W. Erdmann

Abstract
Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology

Objective
The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.

Content
Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC’s and DAC’s, introduction in CMOS technology.

Prerequisites / notice
no prior knowledge in electronics is required

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Problem-solving fostered

Social Competencies
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

see Compulsory Elective Courses Teaching Diploma

Physics Teaching Diploma - Key for Type
O Compulsory E- Recommended, not eligible for credits
W+ Eligible for credits and recommended Z Courses outside the curriculum
W Eligible for credits Dr Suitable for doctorate
<table>
<thead>
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<tr>
<td>V lecture</td>
<td>European Credit Transfer and Accumulation System</td>
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<tr>
<td>G lecture with exercise</td>
<td>Special students and auditors need special permission from the lecturers.</td>
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<tr>
<td>U exercise</td>
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<tr>
<td>S seminar</td>
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<td>K colloquium</td>
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<td>P practical/laboratory course</td>
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<tr>
<td>A independent project</td>
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<tr>
<td>D diploma thesis</td>
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<tr>
<td>R revision course / private study</td>
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</tbody>
</table>
Physics Master

Core Courses

One Core Course in Experimental or Theoretical Physics from Physics Bachelor is eligible; however, this Core Course from Physics Bachelor cannot be used to compensate for the mandatory Core Course in Experimental or Theoretical Physics.

For the category assignment keep the choice "no category" and take contact with the Study Administration (www.phys.ethz.ch/studies/study-administration.html) after having received the credits.

Core Courses in Theoretical Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0861-00L</td>
<td>Statistical Physics</td>
<td>W</td>
<td>10</td>
<td>4V+2U</td>
<td>M. Sigrist</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.</td>
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<tr>
<td>Objective</td>
<td>This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics.</td>
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</tbody>
</table>

Abstract notes

Lecture notes available in English.

Literature

No specific book is used for the course. Relevant literature will be given in the course.

Prerequisites / notice

Knowledge in basic thermodynamics and quantum mechanics.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking

402-0843-00L Quantum Field Theory I

Abstract

This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity.

Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

Objective

The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Seldirection and Self-management

402-0830-00L General Relativity

Abstract

Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.
### Core Courses: Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0257-00L</td>
<td>Advanced Solid State Physics</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>W. Wegscheider</td>
</tr>
<tr>
<td>402-0442-00L</td>
<td>Quantum Optics</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>A. Imamoglu</td>
</tr>
</tbody>
</table>

#### Abstract
- **402-0257-00L** Advanced Solid State Physics
  - This course is an extension of the introductory course on solid state physics.
  - The purpose of this course is to learn to navigate the complex collective quantum phases, excitations and phase transitions that are the dominant theme in modern solid state physics. The emphasis is on the main concepts and experimental examples, both classic ones and those from recent research.

- **402-0442-00L** Quantum Optics
  - This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

#### Objective
- **402-0257-00L** Advanced Solid State Physics
  - The goal is to study how novel phenomena emerge in the solid state.
  - Today's challenges and opportunities in Solid State Physics:

- **402-0442-00L** Quantum Optics
  - The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.

#### Content
- **402-0257-00L** Advanced Solid State Physics
  - Further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

- **402-0442-00L** Quantum Optics
  - The course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics that are covered include:
    - coherence properties of light
    - quantum nature of light: statistics and non-classical states of light
    - light matter interaction: density matrix formalism and Bloch equations
    - quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
    - laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
    - further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

#### Literature
- **402-0257-00L** Advanced Solid State Physics
  - Suggested textbooks:
    - C. Misner, K. Thorne and J. Wheeler: Gravitation
    - S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
    - R. Wald - General Relativity
    - S. Weinberg - Gravitation and Cosmology

- **402-0442-00L** Quantum Optics
  - Literature:
    - Text-books:
      - G. Grynberg, A. Aspect and C. Fabre, Introduction to Quantum Physics
      - R. Loudon, The Quantum Theory of Light
      - Atomic Physics, Christopher J. Foot
      - Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
      - C. Cohen-Tannoudji et al., Atom-Photon-Interactions
      - M. Scully and M.S. Zubairy, Quantum Optics
      - Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics
# Concepts and Theories

L. P. Gallmann

The lecture covers the following topics:

- Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.

## Subject-specific Competencies

- Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, and how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.

## Content

- The lecture covers the following topics:
  
  **a)** Linear pulse propagation: mathematical description of pulses and their propagation in linear optical systems, effect of dispersion on ultrashort pulses, concepts of pulse carrier and envelope, time-bandwidth product
  
  **b)** Dispersion compensation: technologies for controlling dispersion, pulse shaping, measurement of dispersion
  
  **c)** Nonlinear pulse propagation: intensity-dependent refractive index (Kerr effect), self-phase modulation, nonlinear pulse compression, self-focusing, filamentation, nonlinear Schrödinger equation, solitons, non-instantaneous nonlinear effects (Raman/Brillouin), self-steepening, saturable gain and absorption
  
  **d)** Second-order nonlinearities with ultrashort pulses: phase-matching with short pulses and real beams, quasi-phase matching, second-harmonic and sum-frequency generation, parametric amplification and generation
  
  **e)** Relaxation oscillations: dynamical behavior of rate equations after perturbation
  
  **f)** Q-switching: active Q-switching and its theory based on rate equations, active Q-switching technologies, passive Q-switching and theory
  
  **g)** Active modelocking: introduction to modelocking, frequency comb versus axial modes, theory for various regimes of laser operation, Hask master equation formalism
  
  **h)** Passive modelocking: slow, fast and ideally fast saturable absorbers, semiconductor saturable absorber mirror (SESAM), designs of and materials for SESAMs, modelocking with slow absorber and dynamic gain saturation, modelocking with ideally fast saturable absorber, Kerr-lens modelocking, soliton modelocking, Q-switching instabilities in modelocked lasers, inverse saturable absorption
  
  **i)** Pulse duration measurements: rf cables and electronics, fast photodiodes, linear system theory for microwave test systems, intensity and interferometric autocorrelations and their limitations, frequency-resolved optical gating, spectral phase interferometry for direct electric-field reconstruction and more
  
  **j)** Noise: microwave spectrum analyzer as laser diagnostics, amplitude noise and timing jitter of ultrafast lasers, lock-in detection
  
  **k)** Ultrafast measurements: pump-probe scheme, transient absorption/differential transmission spectroscopy, four-wave mixing, optical gating and more
  
  **l)** Frequency combs and carrier-envelope offset phase: measurement and stabilization of carrier-envelope offset phase (CEP), time and frequency domain applications of CEP-stabilized sources
  
  **m)** High-harmonic generation and attosecond science: non-perturbative nonlinear optics / strong-field phenomena, high-harmonic generation (HHG), phase-matching in HHG, attosecond pulse generation, attosecond technology: detectors and diagnostics, attosecond metrology (streaking, RABBITT, transient absorption, attoclock), example experiments
  
  **n)** Ultrafast THz science: generation and detection, physics in THz domain, weak-field and strong-field applications

## Literature


- https://doi.org/10.1007/978-3-030-82532-4

- Prerequisites: Basic knowledge of quantum electronics (e. g., 402-0275-00L Quantenelektronik).

## Competencies

- Subject-specific Competencies: Concepts and Theories assessed, Techniques and Technologies assessed

### 402-0402-00L Ultrafast Laser Physics

<table>
<thead>
<tr>
<th>W</th>
<th>10 credits</th>
<th>3V+2U</th>
<th>L. P. Gallmann</th>
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</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, and how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The lecture covers the following topics:</td>
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<td>a) Linear pulse propagation: mathematical description of pulses and their propagation in linear optical systems, effect of dispersion on ultrashort pulses, concepts of pulse carrier and envelope, time-bandwidth product</td>
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<td>i) Pulse duration measurements: rf cables and electronics, fast photodiodes, linear system theory for microwave test systems, intensity and interferometric autocorrelations and their limitations, frequency-resolved optical gating, spectral phase interferometry for direct electric-field reconstruction and more</td>
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<td>j) Noise: microwave spectrum analyzer as laser diagnostics, amplitude noise and timing jitter of ultrafast lasers, lock-in detection</td>
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<td>n) Ultrafast THz science: generation and detection, physics in THz domain, weak-field and strong-field applications</td>
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</table>

## Literature


### 402-0891-00L Phenomenology of Particle Physics I

<table>
<thead>
<tr>
<th>W</th>
<th>10 credits</th>
<th>3V+2U</th>
<th>P. Crivelli, A. de Cosa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The course focuses on the connection between particle physics theory and experimental results to provide a comprehensive modern view of the Standard Model. The covered topics are quantum electrodynamics (QED) and quantum chromodynamics (QCD).</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The students will deepen the knowledge on particle physics acquired during their bachelor studies. They will be able to apply the basics of relativistic quantum field theory (QFT) to derive the Feynman rules and to apply those to compute QED and QCD processes. They will be able to explain and discuss the connection between theory and experiments.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The course focuses on the connection between particle physics theory and experimental results to provide a comprehensive modern view of the Standard Model. The covered topics are quantum electrodynamics (QED) and quantum chromodynamics (QCD).</td>
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<tr>
<td></td>
<td>Relativistic kinematics</td>
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<tr>
<td></td>
<td>Decay rates and cross sections</td>
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<td></td>
<td>Quantisation of Klein-Gordon (boson) and Dirac (fermion)'s fields</td>
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<td></td>
<td>From the S-matrix to the Feynman rules of QED</td>
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<td>Scattering processes in QED/QCD and running of alpha and alpha_s</td>
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<tr>
<td></td>
<td>Experimental tests of QED and QCD</td>
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</tbody>
</table>

## Literature

- As described in the entity: Lernmaterialien

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Data: 02.07.2024 12:39

Autumn Semester 2024

Page 2058 of 2667
Throughout the past 20 years the realm of quantum physics has entered the domain of information technology in more and more prominent ways. Enormous progress in the physical sciences and in engineering and technology has allowed us to build novel types of information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

The class will be taught in English language. A good understanding of finite dimensional linear algebra is recommended.

This theory part QIP I together with the experimental part 402-0448-02L QIP II (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in Physics.


Throughout the past 20 years the realm of quantum physics has entered the domain of information technology in more and more prominent ways. Enormous progress in the physical sciences and in engineering and technology has allowed us to build novel types of information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

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### Classical and Quantum Parametric Phenomena

**Abstract**
There are numerous physical phenomena that rely on time-dependent Hamiltonians (or parametric driving) to amplify, cool, squeeze or couple resonating systems. In this course, we will introduce parametric phenomena in different fields of physics, ranging from classical engineering ideas to devices proposed for quantum computing.

**Objective**
- Experimentalists who desire to gain a solid theoretical understanding of nonlinear driven-dissipative systems,
- Theorists looking to enter a topical new field,
- Any scientist interested to learn what lies beyond the harmonic resonator.

In the course, the students will grasp the ubiquitous nature of parametric phenomena and apply it to both classical and quantum systems. The students will understand both the theoretical foundations leading to the parametric drive as well as the experimental aspect related to the realizations of the effect. Each student will analyze an independent system using the tools acquired in the course and will present his/her insights to the class.

**Content**
This course will provide a general framework for understanding and linking various phenomena, ranging from the child-on-a-swing problem to quantum-limited amplifiers, to optical frequency combs, and to optomechanical sensors used in the LIGO experiment. The course will combine theoretical lectures and the study of important experiments through literature.

The students will receive an extended lecture summary as well as numerous Python scripts, including some that are base on the QuTiP library. These tools will enable them to apply analytical and numerical methods to a wide range of systems beyond the duration of the course.

### Ultrafast Processes in Solids

**Abstract**
Ultrafast processes in solids are of fundamental interest as well as relevant for modern technological applications. The dynamics of the lattice, the electron gas as well as the spin system of a solid are discussed. The focus is on time resolved experiments which provide insight into pico- and femtosecond dynamics.

**Objective**
After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview over state of the art experimental techniques used to study fast processes.

**Content**
1. Experimental techniques, an overview
2. Dynamics of the electron gas
   2.1 First experiments on electron dynamics and lattice heating
   2.2 The finite lifetime of excited states
   2.3 Detection of lifetime effects
   2.4 Dynamical properties of reactions and adsorbents
3. Dynamics of the lattice
   3.1 Phonons
   3.2 Non-thermal melting
4. Dynamics of the spin system
   4.1 Laser induced ultrafast demagnetization
   4.2 Ultrafast spin currents generated by lasers
   4.3 Landau-Lifschitz-Dynamics
   4.4 Laser induced switching
5. Correlated materials

**Lecture notes**
A full script will be available in the form of chapters from a dedicated book ("Classical and Quantum Parametric Phenomena").

**Literature**
relevant publications will be cited

**Prerequisites / notice**
The lecture can also be followed by interested non-physics students as basic concepts will be introduced.

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**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
402-0469-67L | Classical and Quantum Parametric Phenomena | W | 6 credits | 3G | A. Eichler, A. Grimm

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**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
402-0526-00L | Ultrafast Processes in Solids | W | 6 credits | 2V+1U | Y. M. Acremann
The lecture "Introduction to Magnetism" aims at letting students familiarize themselves with the basic principles of quantum and statistical mechanics. This course tackles the fundamental question of why only a few materials exhibit magnetism in Nature. The origin of atomic magnetic moments and the key mechanisms that govern their interactions are justified starting from fundamental principles. In addition, the influence of thermal fluctuations on magnetic ordering is discussed as well as the formalism to describe magnetic resonance phenomena.

By the end of this course, students will develop the ability to utilize quantum mechanics concepts to estimate the strength of atomic magnetic moments and understand their reciprocal interactions. They will gain proficiency in interpreting experimental measurements on model systems in terms of material composition and an appropriate, phenomenological spin Hamiltonian. For instance, students will be able to recognize whether the magnetic hysteresis observed in some samples arises from slow dynamics or from a phase transition. Lastly, they will be capable of interpreting the occurrence of abrupt transitions or the emergence of characteristic length scales as resulting from the interplay between competing interactions. Altogether, students will acquire the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

Learning material will be made available through Moodle and through the ETH JupyterHub. Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism. Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanoscale transport based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

The physics of the quantum Hall effect and of common nanoscale transport based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.
Semiconductor Materials: Fundamentals and Fabrication

W 6 credits 2V+1U
S. Schön, W. Wegscheider

Abstract
This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objective
Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing

Content
1. Fundamentals of Solid State Physics
1.1 Semiconductor materials
1.2 Band structures
1.3 Carrier statistics in intrinsic and doped semiconductors
1.4 p-n junctions
1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
2.1 Czochalski method
2.2 Floating zone method
2.3 High pressure synthesis
3. Semiconductor Epitaxy
3.1 Fundamentals of Epitaxy
3.2 Molecular Beam Epitaxy (MBE)
3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
4.1 Pressure and temperature
4.2 Reflectometry
4.3 Ellipsometry and RAS
4.4 LEED, AES, XPS
4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

Lecture notes
https://moodle-app2.let.ethz.ch/course/view.php?id=23113

Prerequisites / notice
The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics.

Several topics and corresponding papers will be offered on the moodle page of this lecture.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Media and Digital Technologies
Problem-solving

Social Competencies
Communication
Self-presentation and Social Influence
Sensitivity to Diversity

Personal Competencies
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-direction and Self-management

Selection: Quantum Electronics

Number Title Type ECTS Hours Lecturers
402-0442-05L Advanced Topics in Quantum Optics W 4 credits 2G T. Esslinger

Abstract
The lecture will cover current topics and papers in the wider field of quantum optics in an interactive format. Several papers will be presented by the students in the style of a journal club. Selected papers will be contrasted and their strengths and weaknesses discussed by the students in panel discussions. Recent papers on arXiv.org will be discussed and referee reports

Objective
The aim of the lecture is to deepen and broaden the knowledge about current research in the field of quantum optics. In addition, it will also be discussed and critically examined how research results are communicated via publications and lectures and which techniques are used in the process.

Content
We will select topical fields in quantum optics and quantum science and discuss recently published work.

Topics:
- Atoms or ions-based quantum computing
- Quantum simulation
- Opto-mechanics
- Driven and dissipative quantum systems
- Cavity based atom-light interaction
- Topological photonics

The interactive part of the lecture will include presentations of recent papers, panel discussions of recent papers and the writing of a critical assessment of an arXiv paper in the style of a referee report.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies

Social Competencies
Communication

Personal Competencies
Creative Thinking
Critical Thinking

402-0444-00L Dissipative Quantum Systems

W 6 credits 2V+1U A. Imamoglu

Does not take place this semester.

Abstract
This course builds up on the material covered in the Quantum Optics course. The emphasis will be on quantum optics in condensed-matter systems.
The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

**Lecture notes**
Lecture notes will be provided

**Literature**
C. Cohen-Tannoudji et al., Atom-Photon-Interactions (recommended)
Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics (recommended)
A collection of review articles (will be pointed out during the lecture)

**Prerequisites / notice**
Masters level quantum optics knowledge

<table>
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<th>Competencies</th>
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**402-0457-00L  Quantum Technologies for Searches of New Physics**

*Does not take place this semester.*

**Content**
Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

**Objective**
The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.

**Content**
The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.
- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- C. Quantum Sensors

**Prerequisites / notice**
The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

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**402-0464-00L  Light-Matter Interaction in Semiconductors: Physics and Applications**

**Abstract**
The course presents fundamental aspects of light-matter interaction in semiconductor materials, from basic research topics to opto-electronic devices.

**Objective**
The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these materials, enabled numerous applications as well as the realization of new physical concepts. In this course, we will learn the principles of light-matter interaction in semiconductors for single and multiple particle excitations, and cover opto-electronic applications based on these principles.

**Content**
We will study systems that include quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

**Prerequisites / notice**
Prerequisites: Quantum Mechanics II, Introduction to Solid State Physics, Quantum Electronics

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**402-0465-58L  Intersubband Optoelectronics**

*Does not take place this semester.*

**Abstract**
Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of semiconductors. Because of its inherent taylorability, this system can be seen as the "ultimate quantum designer's material".

**Objective**
The goal of this lecture is to explore both the rich physics as well as the application of these systems for sources and detectors. In fact, devices based on intersubband transitions are now unlocking large area of the electromagnetic spectrum.

**Content**
The lecture will treat the following chapters:
- Introduction: intersubband optoelectronics as an example of quantum engineering
- Technological aspects
- Electronic states in semiconductor quantum wells
- Intersubband absorption and scattering processes
- Mid-IR and THz ISB Detectors
- Mid-infrared and THz photonics: waveguides, resonators, metamaterials
- Quantum Cascade lasers:
  - Mid-IR QCLs
  - THZ QCLs (direct and non-linear generation)
- Further electronic confinement: interlevel Qd transitions and magnetic field effects
- Strong light-matter coupling in Mid-IR and THz range

**Lecture notes**
The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

**Literature**
Mostly the original articles, other useful reading can be found in:
- E. Rosencher and B. Vinter, Optoelectronics, Cambridge Univ. Press
- G. Bastard, Wave mechanics applied to semiconductor heterostructures, Halsted press
Prerequisites / notice

Requirements: A basic knowledge of solid-state physics and of quantum electronics.

**402-0468-15L Nanomaterials for Photonic Devices**

**W** 6 credits 2V+1U  R. Grange, E. Bailly, R. Chapman, V. Falcone, A. Morandi

**Abstract**
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, photonic integrated circuits, ordered and disordered structures...). It starts with concepts of light-matter interactions, fabrication and characterization, the description of the properties and the state-of-the-art applications and devices.

**Objective**
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photronics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.

**Content**
1. Introduction to nanophotonics
2. Wave physics for nanophotonics
3. Characterization of nanomaterials
4. Semiconductors
5. Nonlinear crystals
6. Photonic integrated circuits
7. Optical quantum devices
8. Plasmonics
9. Metasurfaces
10. Graphene & 2D Materials
11. Nanocomposites

**Lecture notes** Slides and book chapter will be available for downloading

**Literature** References will be given during the lecture

**Prerequisites / notice** Basics of solid-state physics (i.e. energy bands) can help

**Competencies**

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**402-0475-00L Terahertz Science and Applications**

**W** 5 credits 2V+1U  E. Abreu

**Abstract**
The Terahertz (THz) range (0.1 – 10 THz), lies between the infrared and microwave spectral regions and has become accessible in the past few years. This new capability has had great impact in scientific research, and has led to technological advances and to the development of a variety of applications and devices. This course provides an introduction to THz science, technology and applications.

**Objective**
The goal of this course is to enable students to determine whether a THz solution can be applied to a particular scientific or technological problem. Armed with the fundamentals of THz science and of current THz technologies, covered in this introductory course, students will be able to weigh the capabilities, advantages and limitations of THz tools to address topics ranging from phonons in solid state systems and molecular vibrations in solutions to medical imaging and wireless communications.

**Lecture notes** Will be distributed via moodle.

**Literature** Yun-Shik Lee, Principles of Terahertz Science and Technology, Springer 2009

**Prerequisites / notice** Basic knowledge in physics, especially in electromagnetism, is required. No formal prerequisites.

**Competencies**

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**402-0492-00L Experimental Techniques in Quantum and Electro-Optics**

**W** 6 credits 2V+1U

**Autumn Semester 2024**
Abstract

We will cover experimental issues in making measurements in modern physics experiments. The primary challenge in any measurement is achieving good signal to noise. We will cover areas such as optical propagation, electronics, noise limits and feedback control. Methods for stabilizing frequencies and intensities of laser systems will also be described.

Objective

I aim to give an in depth understanding of experimental issues for students wishing to work on experimental science. The methods covered are widely applicable in modern physics, since light and electronics are the primary methods by which measurements are made across the field.

Content

The course will cover a number of different areas of experimental physics, including
- Optical elements and propagation
- Electronics and Electronic Noise
- Optical Detection
- Control Theory

Examples from a modern quantum information laboratory will be discussed and illustrated through active devices in the lecture.

### Selection: Particle Physics

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<tr>
<td>402-0457-00L</td>
<td>Quantum Technologies for Searches of New Physics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>P. Crivelli</td>
</tr>
<tr>
<td>402-0621-00L</td>
<td>Introduction to Accelerator Mass Spectrometry</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>C. Vockenhuber, M. Christl, A. Müller, L. Wacker</td>
</tr>
<tr>
<td>402-0715-00L</td>
<td>Low Energy Particle Physics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>A. S. Antognini, D. Ries</td>
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**Prerequisites / notice**
The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

**Abstract**

Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

**Objective**
The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.

**Content**

The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g. Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.
- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

**Abstract**

This course gives an introduction into Accelerator Mass Spectrometry (AMS), the most sensitive method for measuring long-lived radionuclides in natural samples.

**Objective**

Students learn the basic concepts of Accelerator Mass Spectrometry. Based on the underlying physics of ion matter interaction they learn the measurement methods and interpretation of the results for most of the important AMS radionuclides, e.g. radiocarbon (14C), the cosmogenic radionuclides 10Be, 26Al, 36Cl, and anthropogenic nuclides 129I, 236U and other actinides.

**Content**

Introduction into the physics of ion matter interaction: ion stopping, ion scattering and charge exchange.

Mass separation, molecular destruction and isobar separation.

Ion detection and identification.

The measurement methods for all the important radionuclides and the interpretation of their results are discussed on a few examples from the application:

- 14C – radiocarbon dating and environmental studies
- 10Be, 26Al, 36Cl – cosmogenic dating and ice core research
- 129I, 236U, actinides – anthropogenic tracers in the environment
- 14C, 41Ca – biomedical studies
- 60Fe, 244Pu – astrophysics

Alternative methods: ICP-MS, RIMS, ATTA

A visit to the Tandem accelerator and AMS facilities at ETH Hönggerberg is organized as part of lectures and exercises.

**Abstract**

Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate on flagship experiments which have significantly improved our understanding of particle physics today, concentrating mainly on precision experiments with neutrinos, muons and exotic atoms.

**Objective**

You will be able to present and discuss:
- the principle of the experiments
- the underlying technique and methods
- the context and the impact of these experiments on particle physics
Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one directly searches for new particles at energies up to the TeV range. In a complementary way, low energy particle physics indirectly probes the existence of such particles and provides constraints for "new physics", making use of high precision and high intensities.

Besides the sensitivity to effects related with new physics (e.g. lepton flavor violation, symmetry violations, CPT tests, search for electric dipole moments, new low mass exchange bosons etc.), low energy physics provides the best test of QED (electron g-2), the best tests of bound-state QED (atomic physics and exotic atoms), precise determinations of fundamental constants, information about the CKM matrix, precise information on the weak and strong force even in the non-perturbative regime etc.

Starting from a general introduction on high intensity/high precision particle physics and the main characteristics of muons and neutrons and their production, we will then focus on the discussion of fundamental problems and ground-breaking experiments:

- search for rare decays and charged lepton flavor violation
- electric dipole moments and CP violation
- spectroscopy of exotic atoms and symmetries of the standard model
- what atomic physics can do for particle physics and vice versa
- neutron decay and primordial nucleosynthesis
- atomic clock
- Penning traps
- Ramsey spectroscopy
- Spin manipulation
- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling....

**Literature**

Golub, Richardson & Lamoreaux: "Ultra-Cold Neutrons"

Rauch & Werner: "Neutron Interferometry"

Byrne: "Neutrons, Nuclei and Matter"

Klapdor-Kleingrothaus: "Non-Accelerator Particle Physics"

**Prerequisites / notice**

Einführung in die Kern- und Teilchenphysik / Introduction to Nuclear- and Particle-Physics

**402-0767-00L**

**Neutrino Physics**

Theoretical basis and selected experiments to determine the properties of neutrinos and their interactions (mass, spin, helicity, chirality, oscillations, charge-parity violation, interactions with leptons and quarks) and implications on physics beyond the Standard Model of elementary particles as well as on Cosmology.

**Objective**

Critically analyze and elaborate the neutrino production and detection techniques. Derive the theory of neutrino scattering and analyze its implications in neutrino experiments. Analyze the phenomenology of neutrino oscillations and its implication on the physics Beyond the Standard Model of particles. Derive the main concepts of the theory of neutrino masses within and beyond the Standard Model of particles and analyze the experimental techniques related to the measurement of the neutrino masses. Describe the role of neutrinos in Cosmology and make connections with current and future neutrino experiments. Review the experimental configurations and analyze the challenges in searches for leptonic Charge-Parity symmetry violation and the measurement of the neutrino mass hierarchy.

1. Introduction to Neutrinos and Neutrino Sources;
2. Neutrino Detectors
3. Neutrino Interactions
4. Neutrino Oscillations
5. Nature of Neutrino masses
6. Neutrinos in Cosmology
7. Search for leptonic Charge Parity violation and precision measurement of the neutrino oscillation probability

**Literature**


D.O. Caldwell, Current Aspects of Neutrino Physics, Springer.


K.Zuber, “Neutrino Physics” CRC Press 2020

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Problem-solving: assessed

**Personal Competencies**

- Creative Thinking: fostered
- Critical Thinking: assessed

**402-0725-00L**

**Experimental Methods and Instruments of Particle Physics**


**Objective**

Acquire an in-depth understanding and overview of the essential elements of experimental methods in particle and astroparticle physics.

1. Examples of modern experiments
2. Introduction to particle sources and accelerators
4. Detailed analysis of non-electronic, noble element, solid state, scintillator-based and Cherenkov particle detectors
5. Experimental techniques for particle tracking, calorimetry and identification
6. Monte Carlo simulations, trigger and data acquisition system readout

**Literature**

Einführung in die Kern- und Teilchenphysik / Introduction to Nuclear- and Particle-Physics
Lecture notes are handed out regularly.

Literature
- H. Kalosnik and N. Wermes, "Particle Detectors: Fundamentals and Applications".
- C. Grupen and B. Schwartz, "Particle Detectors".
- G. F. Knoll, "Radiation Detection and Measurements".

Competencies
- Subject-specific Competencies: assessed
- Personal Competencies: fostered

402-0777-00L Particle Accelerator Physics and Modeling I

**Description**
This course is the second of two courses, introducing particle accelerators from a theoretical point of view and covers state-of-the-art modelling techniques.

**Objective**
You obtain a theoretical understanding of the building blocks of particle accelerators. Modern numerical analysis tools allow you to model state-of-the-art particle accelerators. We will develop a Julia simulation tool (JuliAccel.jl) that reflects the theory from the lecture.

**Content**
Here is the rough plan of the topics, however the actual pace may vary relative to this plan.

- Recap of Relativistic Classical Mechanics and Electrodynamics
- Building Blocks of Particle Accelerators
- Lie Algebraic Structure of Classical Mechanics and Application to Particle Accelerators
- Symplectic Maps & Analysis of Maps
- Symplectic Particle Tracking
- Collective Effects
- Linear & Circular Accelerators

**Lecture notes**
Lecture notes in exceptional cases for students at BSc level can attend. This lecture is also suited for PhD. students.

**Prerequisites**
Physics, Computational Science (RW) at MSc. Level

**Literature**
- K. Fossheim & A. Sudbo, "Superconductivity: Physics and Applications"
- H. Stolz, "Supraleitung" (German)
- J. B. Ketterson & S. N. Song, "Superconductivity"
- A. A. Abrikosov, "Fundamentals of the Theory of Metals"

402-0851-00L QCD: Theory and Experiment

**Description**
This lecture provides an introduction to the theoretical aspects and experimental tests of QCD, with emphasis on perturbative QCD and related experiments at colliders.

**Objective**
Knowledge acquired on basics of perturbative QCD, both of theoretical and experimental nature. Ability to perform simple calculations of perturbative QCD, as well as to understand modern publications on theoretical and experimental aspects of perturbative QCD.

**Content**
QCD Lagrangian and Feynman Rules
QCD running coupling
Parton model
DGLAP
Basic processes
Experimental tests at lepton and hadron colliders
Measurements of the strong coupling constant

**Literature**
2) R. K. Ellis, W. J. Stirling, B. R. Webber: "QCD and Collider Physics" (Cambridge Monographs on Particle Physics, Nuclear Physics & Cosmology)

**Prerequisites / notice**
Will be given as block course, language: English.
For students of both ETH and University of Zurich.

**Selection: Theoretical Physics**

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<tr>
<td>401-2813-00L</td>
<td>Programming Techniques for Scientific Simulations I</td>
<td>W</td>
<td>5</td>
<td>4G</td>
<td>R. Käppeli</td>
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<td>402-0580-00L</td>
<td>Superconductivity</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>V. Geshkenbein</td>
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**Literature**
- M. Tinkham, "Introduction to Superconductivity"
- P. G. de Gennes, "Superconductivity Of Metals And Alloys"
- A. A. Abrikosov, "Fundamentals of the Theory of Metals"
- J. B. Ketterson & S. N. Song, "Superconductivity"
- H. Stolz, "Supraleitung" (German)
- K. Fossheim & A. Sudbo, "Superconductivity: Physics and Applications"
### 402-0490-00L Advanced Methods in Quantum Many-Body Theory

**Abstract**
Advanced theoretical methods for analyzing quantum many-body systems will be reviewed. We will discuss equilibrium Green's functions, Keldysh formalism for nonequilibrium phenomena, variational approaches. Specific models that will be considered include systems with dissipation, polaron, interacting electrons, electron-photon systems, transport in mesoscopic systems, superconductivity, cavity QED.

**Objective**
Introduce advanced theoretical methods for analyzing quantum many-body systems including Green's functions and variational approaches.

**Prerequisites / notice**
This class assumes familiarity with quantum mechanics, including second quantization, and condensed matter physics.

**Content**
- Introduction to quantum statistical mechanics
- Advanced techniques of quantum field theory
- Quantum and classical many-body systems
- Quantum computing and quantum information

**Literature**

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies

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### 402-0809-00L Introduction to Computational Physics

**Abstract**
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

**Objective**
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

**Content**
- Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.
- Lecture notes and slides are available online and will be distributed if desired.

**Literature**
- Lecture notes and slides are available online and will be distributed if desired.

**Prerequisites / notice**
Lecture and exercise lessons in english, exams in German or in English

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies

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### 402-0822-13L Introduction to Integrability

**Abstract**
This course gives an introduction to the theory of integrable systems, related symmetry algebras and efficient calculation methods. Intelligible systems are a special class of physical models that can be solved exactly due to an exceptionally large number of symmetries. Examples of integrable models appear in many different areas of physics including classical mechanics, condensed matter, 2d quantum field theories and lately in string- and gauge theories. They offer a unique opportunity to gain a deeper understanding of generic phenomena in a simplified, exactly solvable setting. In this course we introduce the notion and formulation of integrability in classical and quantum mechanics. We discuss various efficient methods for constructing solutions and eigenstates in these models. Finally, we elaborate on the enhanced symmetries that underly integrable models.

**Content**
- Classical Integrability
- Algebraic Methods for Integrability
- Classical Spin Chains
- Spectral Curves and Inverse Scattering
- Quantum Spin Chains
- Bethe Ansatz
- Classical and Quantum Algebra

**Literature**

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Sensitivity to Diversity
- Personal Competencies: Adaptability and Flexibility

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### 402-0836-16L Quantum Simulations of Gauge Theories

**Abstract**
This course introduces various aspects of lattice quantum field theory (QFT), gauge symmetries, quantum simulators, and implementation schemes. Other than highlighting the strengths and weaknesses of the lattice formulation of QFT's suitable for Monte Carlo simulations, the course discusses practical realization of quantum simulators for gauge theories.

**Objective**
After acquiring the foundations on lattice formulation of gauge theories, and challenges of conventional Monte Carlo simulation approaches, the students will learn about different strategies for quantum simulation of gauge theories and their implementation on digital and analog quantum devices.

**Content**
1. Background and Motivation
   1.1 From Quantum Field Theories to Lattice field theories;
   1.2 Lattice Gauge Theories - Lagrangian formulation, gauge symmetries, observables;
   1.3 Monte Carlo simulations, sign problems, and complex actions.
2. Road-map for Quantum Simulation of Gauge Theories
   2.1 Hamiltonian formulation, Wilson's formulation, and the infinite Hilbert spaces;
   2.2 Finite Hilbert spaces: Z(N) gauge theories. Dualizing the Ising model and relation with the toric code;
   2.3 Finite Hilbert spaces: Quantum link models for Abelian gauge theories;
   2.4 Finite Hilbert spaces: Quantum link models for non-Abelian gauge theories;
   2.5 Exploring the physics of gauge theories - phases, dynamics, and thermalization;
   2.6 Exploring methods for gauge theories - exact diagonalization, tensor networks, Monte Carlo.
3. Quantum Simulation Approaches and Platforms
   3.1 Digital vs. analog quantum simulations;
   3.2 Proposals for simulations of gauge theories, realization, and perspectives.

**Literature**

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Sensitivity to Diversity
- Personal Competencies: Adaptability and Flexibility
- Critical Thinking

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The focus of the course is on Effective Field Theories (EFTs) and their interplay with dispersion theory. Lecture notes will be handed out (in English).

This course will review recent progress in realizing strongly correlated many-body systems with ultracold atoms. Both theory and

This course provides a pedagogical introduction to Quantum Electrodynamics. Subjects covered in this class include: Bose-Einstein condensation of weakly interacting atomic gases; analogue gravity with BEC; spinor

The course gives an introduction to symmetry groups in physics. It explains the relevant mathematical background (finite groups, Lie

Chromodynamics (QCD). We will briefly discuss the application of this concept to describe a class of theories beyond the SM in which the SM Higgs arises as a composite state of a new confining sector.

The second focus of the course is on dispersion theory and its interplay with EFTs. We will discuss how to make use of the constraints from unitarity of the S-matrix and analyticity of scattering amplitudes, in order to extend the range of validity of the theoretical description compared to pure EFT methods. We will also discuss how to obtain constraints on EFT parameters from unitarity and analyticity. We will discuss the application of these methods both in the context of low-energy strong interaction and physics beyond the Standard Model.

- Introduction to Effective Field Theories
- Decoupling and matching
- Renormalization group resummation
- The Standard Model Effective Field Theory (SMEFT)
- Chiral Lagrangians
- Unitarity of the S-matrix
- Analyticity and dispersion relations

Prerequisites / notice QFT-I (mandatory) and QFT-II (highly recommended)

This course will review recent progress in realizing strongly correlated many-body systems with ultracold atoms. Both theory and experiments will be discussed with an emphasis on the connection between the physics of ultracold atoms and correlated electron systems. The course will explore unique features of ultracold atoms such as dynamical control of Hamiltonians and single atom resolution.

This course provides the background needed to understand current research in ultracold atoms. Lecture material is complemented by homework problems that give hands-on experience with the concepts introduced in class, as well as a final project that involves reviewing an influential paper in a relevant research area and presenting a summary in class.

Subjects covered in this class include: Bose-Einstein condensation of weakly interacting atomic gases; analogue gravity with BEC; spinor condensates; noninteracting atoms in optical lattices and probes of band structure; state dependent lattices and synthetic gauge fields; Bose Hubbard mode; quantum magnetism with ultracold atoms in optical lattices; quantum noise measurements as a probe of many-body states; Feshbach resonance; fermion pairing close to Feshbach resonance; the BCS-BEC crossover; polarons in systems of bosonic and fermionic ultracold atoms; fermionic Hubbard model; realizing and probing topological states with ultracold atoms; one dimensional systems; SU(N) magnetism and Kondo physics with alkaline-earth atoms; systems with long range interactions; many body localization; superradiance and Dicke quantum phase transitions in optical cavities for bosonic and fermionic atoms.

Lecture notes Lecture notes will be handed out (in English).

Prerequisites / notice This course requires knowledge of MSc level Quantum Mechanics and Statistical Physics. Prior knowledge of atomic and solid state physics is useful but not necessary.

This course will review recent progress in realizing strongly correlated many-body systems with ultracold atoms. Both theory and experiments will be discussed with an emphasis on the connection between the physics of ultracold atoms and correlated electron systems. The course will explore unique features of ultracold atoms such as dynamical control of Hamiltonians and single atom resolution.

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Lecture notes Lecture notes will be handed out (in English).

Prerequisites / notice This course requires knowledge of MSc level Quantum Mechanics and Statistical Physics. Prior knowledge of atomic and solid state physics is useful but not necessary.

This course introduces to Quantum Electrodynamics. This course provides a pedagogical introduction to Quantum Electrodynamics. Students will be introduced to the theory of Quantum Electrodynamics, and the use of Feynman diagrams to arrive at theoretical predictions for phenomena related to the interaction of light and matter. The course is designed to complement Quantum Field Theory I for those students with a special interest in theoretical elementary particle physics.

The course will cover:
- an introduction to QED as the quantum theory of interactions of light and matter.
- Feynman rules for QED
- Amplitudes and cross sections for simple processes in QED
- Gauge invariance and the Ward identity
- Ultraviolet singularities and Renormalization
- Infrared singularities and their cancellation
- The Uehling potential and the Lamb shift
- Anomalous magnetic moments

Lecture notes Will be provided at the Moodle site for the course.

Literature Literature will be provided at the Moodle site for the course.

Competencies Subject-specific Competencies

Method-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Problem-solving

Prerequisites / assessed assessed assessed assessed

This course offers an introduction to symmetry groups in physics. It explains the relevant mathematical background (finite groups, Lie groups and algebras as well as their representations), and illustrates their important role across modern physics.

The aim of the course is to give a self-contained introduction into finite group theory as well as Lie theory from a physicists point of view. Abstract mathematical constructions will be illustrated with examples from physics.
Content
Finite group theory, including representation theory and character methods; applications to crystallography and solid state physics.
The symmetric group and the structure of its representations; applications to identical particles. Clifford algebras; application to relativistic wave equations. Simple Lie algebras and their finite-dimensional representations. Description of representations of SU(N) in terms of Young diagrams; applications in particle physics.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Problem-solving</td>
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</table>

402-0886-00L QCD and Scattering Amplitudes

W 6 credits 2V+1U A. Gehrmann-De Ridder

Special Students UZH must book the module PHY564 directly at UZH.

Abstract
The course presents the quantum field theory of the strong interaction (quantum chromodynamics, QCD) and discusses its applications to particle physics observables.

Objective
The course aims to familiarize the students with the concepts and applications of QCD and to introduce them to modern techniques for computations in QCD.

Content
Content:
* Review of non-Abelian gauge theories
* Renormalization of QCD and running coupling constant
* Jet observables in e+e- annihilation
* QCD at lepton-proton colliders
* Multiparticle production
* Spinor-helicity formalism
* Perturbation theory techniques: loops and phase space

Prerequisites / notice
The course assumes prior knowledge of the content of the quantum field theory 1+2 lectures.

Literature
M.B. Green, J.H. Schwarz, E. Witten, Superstring Theory I, CUP (1987).

Method-specific Competencies

<table>
<thead>
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402-0897-00L Introduction to String Theory

W 6 credits 2V+1U J. Brödel

Abstract
String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

Objective
Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

Content
- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- critical dimension and no-ghost theorem
- D-branes, T-duality
- two-dimensional conformal field theories

Prerequisites / notice
Recommended: Quantum Field Theory I (in parallel)

Literature
Astronomical Observations and Instrumentation

W 6 credits 2V+1U L. Harra

Does not take place this semester.

Abstract
Astronomical techniques and observing strategies are presented with a particular emphasis on currently available professional telescopes of the European Southern Observatory.

Objective
The course shall provide a basic understanding of the potential and limitation of different types of modern astronomical observations for early career researchers. The course will present technical aspects which are important to prepare, to carry out and to calibrate different types of astronomical measurements: photometry, spectroscopy, astrometry, polarimetry and others. Many practical examples will be discussed including methods for the detection of physical samples of cosmic dust. Also scientific aspects of instrumental projects and observational programs are addressed. An opportunity to contribute to solar spacecraft operations will be available during the course.

Content
1. Introduction: research projects in astronomical observations
2. Observables: electromagnetic radiation, particles
3. Optical telescopes: Optics, types, mechanical concepts, examples
4. Detectors: CCDs, IR detectors, basic data reduction steps
5. Photometry: signal extraction, calibration, faint sources, etc.
6. Spectroscopy: spectographs, calibration, spectral features
7. Introduction to solar space instrumentation
8. Space observations of cosmic dust: introduction, remote sensing, in situ instruments, sample return, calibration, data analysis and practical examples
9. Speckles and adaptive optics: atmosphere, AO-systems
10. Polarimetry: measuring principles
11. Interferometry

Lecture notes
Notes will be distributed.

Literature

402-0355-00L Planet Formation

W 4 credits 2V J. Szulágyi

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2070 of 2667
Lecture Series about selected topics of space research and exploration consisting of individual talks given by different leading experts from Analytical Competencies fostered assessed Subject-specific Competencies 2V+1U

The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay between the scientifically desirable and the technologically possible. The 'Lecture Series: Space Research and Exploration' aims to shed light on key questions engaged by leading scientists and engineers today. It consists of weekly lectures, given by different speakers with vast experience in their respective field (e.g., Human Spaceflight, System Engineering of Spacecraft, Space Life Sciences, Space-based astrophysics). Subsequent to the talk, the student will have the opportunity to deepen their understanding by asking questions to the presenter in a moderated Q&A.

Confirmed speakers will be announced by the start of the semester (see lecture from last year for previous speakers).

402-0368-07L Lecture Series: Space Research and Exploration W 1 credit 2V S. P. Quanz

Abstract Lecture Series about selected topics of space research and exploration consisting of individual talks given by different leading experts from academia and industry.

Objective Attending students will
- experience the interdisciplinarity of space research and exploration spanning physics, engineering, geosciences, biology and more
- get familiar with the Swiss space research and industry landscape
- enhance their communication skills by broadening their research horizon
- have the opportunity for direct learning by posing questions to experts

Content The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay between the scientifically desirable and the technologically possible. The 'Lecture Series: Space Research and Exploration' aims to shed light on key questions engaged by leading scientists and engineers today. It consists of weekly lectures, given by different speakers with vast experience in their respective field (e.g., Human Spaceflight, System Engineering of Spacecraft, Space Life Sciences, Space-based astrophysics). Subsequent to the talk, the student will have the opportunity to deepen their understanding by asking questions to the presenter in a moderated Q&A.

Confirmed speakers will be announced by the start of the semester (see lecture from last year for previous speakers).

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management assessed

402-0368-11L Earth - A (Unique?) Habitable Planet W 6 credits 2V+1U S. P. Quanz

Does not take place this semester.

Abstract While thousands of extrasolar planets are known to orbit stars other than the Sun, Earth is - until now - the only planet known to be habitable. This lecture takes an interdisciplinary view on Earth as a habitable planet, how it formed, evolved, allowed life to flourish, and how its future might look like. Would we be able to identify another Earth-like planet amongst the population of exoplanets?

Objective Attending students will
• understand Earth place in the cosmos
• learn tools to discern the history of Earth and other planets
• explore the origin and co-evolution of Earth and life
• put Earth in context with extrasolar planets

Content This lecture focuses on our home planet - Earth - from an interdisciplinary perspective. As the search for habitable - and potentially even inhabited - extrasolar planets is one of the most dynamic research fields in modern astrophysics, understanding what makes a planet habitable is a topic of increasing importance; and a highly interdisciplinary topic. In broad brushes, this lecture will discuss the building blocks of planetary systems and their formation, how we can learn about the history of Earth and other planets, what major epochs we can identify over the course of Earth’s 4.5 billion year history, when life arose on Earth and what impact it had on Earth’s evolution, how the future Earth might look like, and - last but certainly not least - how we can search for an Earth-like planet in our cosmic neighbourhood and what our chances are to be successful.

402-0371-62L Cosmological Probes W 6 credits 2V+1U A. Refregier
Our understanding of the universe has made great progress recently thanks to the combination of several cosmological probes such as the cosmic microwave background, galaxy clustering, gravitational lensing, and supernovae. After a review of cosmology, this course will cover the physics of these different probes along with their application, combination and use to measure cosmological parameters.

The goal of this course is to provide an understanding of the physics, application and combination of cosmological probes, and highlight current research topics.

Credits or current enrollment in Astrophysics I and II is recommended but not required.

**402-0398-00L**  
**Cosmic Dust in the Solar System: From Science Case to Mission Design**

This course provides students with a basic understanding of the science of cosmic dust in the solar system and how to measure it with space-based satellites and instrumentation. The lectures include the physical processes of both interplanetary and interstellar dust, trajectory simulations (i.e. orbital dynamics), in situ measurement techniques, and mission design aspects.

At the end of the course, students are able to classify the different types of dust in the solar system, and to relate them to their sources, sinks, their importance for planetary science and astronomy, physical processes, and appropriate measurement techniques. They will be able to simulate dust trajectories and use them to gain insight in how orbital dynamics and the space environment shape them. Students can design a basic concept of a space mission for dust measurements. The skills taught in this course will be useful to students in a broader way for planetary sciences.

**Content**

1. Introduction, course outline, historical notes, interstellar and interplanetary dust, dust in the solar system, sources, sinks, importance for science
2. Dust instrumentation and observables: ground-based, space-based and sample return techniques, calibration of dust instruments in the lab
3. Dust dynamics: recap basic aspects of orbital dynamics, the SPICE toolkit, types of orbits
4. Dust dynamics: space environment, dust processes and implications (e.g. in the early solar system), dust charging, consequences for dynamics, comparison with spacecraft dynamics
5. Dust models and dust data analysis: types of models and their limitations, data analysis
6. Mission design aspects: orbits, mission design limitations, advantages, disadvantages, instrument accommodation, example missions

**Lecture notes**  
Slides will be provided before each lecture.

**Literature**  
Interplanetary dust (freely available online)  
https://link.springer.com/book/10.1007/978-3-642-56428-4  
Cosmic dust from the laboratory to the stars (ETH Library)  

**Prerequisites / notice**  
The exercise solutions are performed in the Julia programming language.

**402-0713-00L**  
**Astro-Particle Physics I**

This lecture gives an overview of the present research in the field of Astro-Particle Physics, including the different experimental techniques. In the first semester, main topics are the charged cosmic rays including the antimatter problem. The second semester focuses on the neutral components of the cosmic rays as well as on some aspects of Dark Matter.

**Abstract**  
Successful students know:  
- experimental methods to measure cosmic ray particles over full energy range  
- current knowledge about the composition of cosmic ray  
- possible cosmic acceleration mechanisms  
- correlation between astronomical object classes and cosmic accelerators  
- information about our galaxy and cosmology gained from observations of cosmic ray

**Content**  
First semester (Astro-Particle Physics I):  
- definition of 'Astro-Particle Physics'  
- important historical experiments  
- chemical composition of the cosmic rays  
- direct observations of cosmic rays  
- indirect observations of cosmic rays  
- 'extended air showers' and 'cosmic muons'  
- 'knee' and 'ankle' in the energy spectrum  
- the 'anti-matter problem' and the Big Bang  
- 'cosmic accelerators'

**Lecture notes**  
See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/

**Literature**  
See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/
**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

**Social Competencies**
- Communication: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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**402-0738-10L Bayesian Statistical Methods and Data Analysis**

**W 6 credits 3G T. Tröster**

**Abstract**

The course covers various data analysis methods using Bayesian statistics, with a focus on practical problem solving. We will go over a brief introduction to probability theory, Bayesian reasoning, and how to build a statistical model and compare it to data. The course builds towards analysing data from real astrophysical problems, using both classical statistical methods and machine learning.

**Objective**

The goal of this course is to introduce students to Bayesian statistics and prepare them to solve statistical inference problems in contemporary (astrophysics) research. After introducing Bayesian statistics and general methodology, the course focuses on building up a structured approach to analyse increasingly complex data and models. The methods are general and applicable beyond (astro)physics, however.

**Content**

Topics covered include:
- Review of probability theory:
  - Independence, joint and conditional probabilities
  - Univariate and multivariate probability distributions
  - Change of variables

Bayesian statistics:
- Bayes’ theorem
- Priors
- Bayesian reasoning
- Posterior distributions, model checking, and model comparison Tools for statistical inference:
- Various sampling methods, such as Markov chain Monte Carlo (Metropolis Hastings, slice sampling, Hamiltonian Monte Carlo) and nested sampling
- Simulation-based inference
- PCA, bootstrap
- Gaussian processes and Gaussian random fields
- Machine learning and probabilistic programming

The lectures are accompanied with code examples, both to illustrate the covered topics and to demonstrate how the theoretical concepts can be implemented in practical computational inference problems.

**Prerequisites / notice**

Prior knowledge of probability theory and statistics would be useful but not required. Since most of the course makes use of computational methods, some knowledge of scientific computing with Python (e.g. numpy, scipy) will be assumed.

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**Selection: Further Electives**

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<th>Number</th>
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<td>402-0220-MSL</td>
<td>Extended Research Project</td>
<td>W</td>
<td>4 credits</td>
<td>8A</td>
<td>Supervisors</td>
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</tbody>
</table>

This course can only be booked together with a research project (402-0218-MS). This extension is not available for the options Proseminars, Particle Physics at PSI, Medical Physics and Experimental Foundations of Particle Physics. The extension is only possible with the agreement of the supervising professor. The extension must be booked at the same time as the research project.

**Abstract**

Extension of the Research Project

Students are enabled to:
- expand their knowledge in a specific area of physics,
- conduct a project (a) in a research laboratory or (b) on a specific topic of theoretical physics,
- discuss their project results and conclusions in a team,
- present their findings in written and oral form.

The extension allows for a more in-depth research experience.
402-0247-00L  
Electronics for Physicists I (Analogue)  
W 4 credits  2V+2P  G. Bison, W. Erdmann

Abstract
Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology

Objective
The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.

Content
Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC’s and DAC’s, introduction in CMOS technology.

Prerequisites / notice
no prior knowledge in electronics is required

Competencies
Subject-specific Competencies  Concepts and Theories  assessed  
Techniques and Technologies  assessed  
Method-specific Competencies  Analytical Competencies  assessed  
Decision-making  assessed  
Media and Digital Technologies  fostered  
Problem-solving  assessed  
Project Management  fostered  
Social Competencies  Communication  assessed  
Cooperation and Teamwork  fostered  
Sensitivity to Diversity  fostered  
Negotiation  fostered  
Personal Competencies  Adaptability and Flexibility  fostered  
Creative Thinking  assessed  
Critical Thinking  fostered  
Integrity and Work Ethics  assessed  
Self-awareness and Self-reflection  fostered  
Self-direction and Self-management  fostered

402-0737-00L  
Energy and Sustainability in the 21st Century (Part I)  
W 6 credits  2V+1U  P. Morf

Abstract
Part I of this course covers the energy-related topics in this two-semester course. The importance of energy to life and our modern culture is explored and placed in the perspective of the ongoing energy transition in the context of necessary and urgent decarbonization efforts.

Objective
How much energy do we need and how can it be provided in a way that enables a sustainable existence?

Content
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literature
The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
Clean Disruption of Energy and Transportation, T. Seba 2014
Energy and Civilization: A History, V. Smil, 2018

Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2074 of 2667
This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has it price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling. Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

Lecture notes
Lecture handouts will be posted online.

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<tr>
<td>227-1033-00L</td>
<td>Neureomorphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu, M. Payvand</td>
</tr>
</tbody>
</table>

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module IN404 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective**

Understanding of the characteristics of neuromorphic circuit elements.

**Content**

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

**Prerequisites**

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

**Literature**

Various publications.

**Selection: Medical Physics**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manser</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.</td>
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<tr>
<td>Objective</td>
<td>Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.</td>
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<tr>
<td>Content</td>
<td>The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.</td>
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<tr>
<td>Lecture notes</td>
<td>A script will be provided.</td>
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<tr>
<td>Prerequisites</td>
<td>For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
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<tr>
<td></td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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</tbody>
</table>

| 402-0674-00L   | Physics in Medical Research: From Atoms to Cells | W    | 6    | 2V+1U | B. K. R. Müller      |
| Abstract       | Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitelial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells. |
| Prerequisites  |                                                    |      |      |       |                     |
| Competencies   | Subject-specific Competencies                  |      |      |       |                     |

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Data: 02.07.2024 12:39

Autumn Semester 2024

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Computer assistance and robotics have entered many fields of interventional medicine, shaping the way high-precision procedures are performed today. In this lecture series, we will present the methods and technologies used in image-guided radiotherapy, from the use of medical images to model the patient's anatomy to intraoperative navigation and registration.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxideric and organic surfaces are introduced. The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the size of the critical nuclei and other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violent to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biospies.

<table>
<thead>
<tr>
<th>465-0970-00L Image Guided Medical Interventions</th>
<th>W 6 credits</th>
<th>2V+1U</th>
<th>G. Fattori</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Computer assistance and robotics have entered many fields of interventional medicine, shaping the way high-precision procedures are performed today. In this lecture series, we will present the methods and technologies used in image-guided radiotherapy, from the use of medical images to model the patient's anatomy to intraoperative navigation and registration.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Upon completion of the course, students are able to explain the methods and technologies for image guidance and stereotactic radiotherapy. In particular, they are able to design the calibration of in-room imaging solutions and other navigation systems to verify and correct patient position in high-precision radiotherapy. In addition, they are familiar with common tools used in medical image processing research.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Basics of imaging and image processing for IGRT:</td>
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<tr>
<td></td>
<td>* 3D/4D imaging.</td>
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<tr>
<td></td>
<td>* Segmentation (thresholding, region growing and similar).</td>
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<td></td>
<td>* Filtering (morphological filters and similar fundamentals).</td>
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<td></td>
<td>* Modelling and rendering of volumes and surfaces.</td>
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<td></td>
<td>* Image registration.</td>
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<td></td>
<td>* Conventions for position and orientation representation.</td>
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<tr>
<td><strong>Technologies and methods for localisation and navigation:</strong></td>
<td>* Reference systems mapping.</td>
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<td></td>
<td>* Kinematic of a robotic treatment couch.</td>
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<td></td>
<td>* Optical tracking systems, calibration and use.</td>
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<td></td>
<td>* Registration of points and surfaces.</td>
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<td>* In-room imaging and geometry calibration of X-ray systems.</td>
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<tr>
<td></td>
<td>* 2D/3D and 3D/3D registration.</td>
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<td></td>
<td>* Organ motion.</td>
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<tr>
<td><strong>Technologies and methods for on-line treatment verification</strong></td>
<td>* In-room imaging for verification of proton therapy treatment</td>
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</tbody>
</table>

If you like playing with medical imaging and computer vision tools, you could be interested in this course.

### Selection: Environmental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1239-00L</td>
<td>Aerosols I: Physical and Chemical Principles</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>M. Gysel Beer, D. Bell, E. Weingartner</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Physical and chemical principles:</td>
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<td>The students...</td>
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<td>- know the processes and physical laws of aerosol dynamics.</td>
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<td>- understand the thermodynamics of phase equilibria and chemical equilibria.</td>
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<td>- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.</td>
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<td>Experimental methods:</td>
<td>The students...</td>
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<td>- know the most important chemical and physical measurement instruments.</td>
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<td>- understand the underlying chemistry and physics.</td>
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<tr>
<td><strong>Environmental impacts:</strong></td>
<td>The students...</td>
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<td></td>
<td>- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.</td>
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<td></td>
<td>- know the most important climate impacts of atmospheric aerosols.</td>
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<tr>
<td></td>
<td>are aware of the health impacts of atmospheric aerosols.</td>
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<tr>
<td>Lecture notes</td>
<td>materiel is distributed during the lecture</td>
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</tbody>
</table>
This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clapeyron equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to use thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in radiosonde ascents. Atmospheric mixing processes are introduced as a basis for fog formation. The concept of an air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=22731

An electronic version of this book can be obtained via the ETH library.

pdf-files of the revised book will be provided on moodle on a chapter-by-chapter basis.

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.
Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes
Dynamics of large-scale atmospheric flow

Literature
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Prerequisites / notice
Physics I, II, Environmental Fluid Dynamics

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Social Competencies
- Cooperation and Teamwork fostered

Personal Competencies
- Critical Thinking assessed

651-4053-05L Boundary Layer Meteorology

Abstract
The Planetary Boundary Layer (PBL) constitutes the lower part of the atmosphere, is characterized by turbulent mixing and ensures the exchange of energy, mass and momentum between the Earth’s surface and the atmosphere. The course provides the theoretical background for understanding the structure and dynamics of the PBL. Idealized concepts are reviewed and contrasted to real world applications.

Objective
Students are able to:
- Name the basic approaches needed to describe planetary boundary layer flows and associated turbulent exchange processes.
- Apply these concepts to answer comprehension questions and solve simple problems related to the structure and dynamics of the PBL.
- Independently judge the applicability of learned concepts and tools to real-world situations.

Content
- Introduction
- PBL structure and stability
- Turbulence and turbulent transport
- Scaling and similarity theory
- Spectral characteristics
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Rough surfaces and the roughness sublayer
- Complex terrain

Lecture notes
available (i.e. in English)

Literature

Prerequisites / notice
Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Problem-solving fostered

Personal Competencies
- Creative Thinking fostered
- Critical Thinking assessed

Introduction to differential manifolds and differential geometry.

Abstract
Introduce the language, tools, and basic results of differentiable manifolds, tensors, Riemannian geometry, and related geometric structures. Relate geometric intuition to formulas involving curvature, derivatives and tensors.

Objective
Learn to compute, describe, prove, and solve problems in the language of differential geometry.

Content
Submanifolds of \( \mathbb{R}^n \), immersions, submersions, and embeddings, Sard's Theorem, abstract differentiable manifolds, charts, vector fields and flows, vector bundles, tensor fields, covariant derivatives, parallel transport, Riemannian metrics, geodesics, Riemann curvature tensor. Complete manifolds, Hopf-Rinow theorem. Many examples including curves, surfaces, hyperbolic space, \( S^3 \), the unit quaternions, the Gauss-Bonnet theorem, etc.
This following books were inherited from before. The only one I know is DoCarmo.

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie, Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Literature

John M. Lee: Introduction to Smooth Manifolds
John M. Lee: Introduction to Riemannian Manifolds

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Problem-solving: assessed

Social Competencies
- Sensitivity to Diversity: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

401-3461-00L Functional Analysis I

W 9 credits 4V+1U M. Burger

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

Abstract

Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed graph theorem; spectral theory of self-adjoint operators in Hilbert spaces. Basics of Sobolev spaces.

Objective

Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature

Recommended references include the following:


401-3601-00L Probability Theory

W 9 credits 4V+1U V. Tassion

Abstract

Basics of probability theory and the theory of stochastic processes in discrete time

Objective

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Measure theory formalism and probability theory, Dynkin's lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.

Lecture notes will be available in electronic form.

Literature

- H. Bauer, Probability Theory, de Gruyter 1996
- J. Jacod and P. Protter, Probability essentials, Springer 2004
- D. Williams, Probability with martingales, Cambridge University Press 1991

Prerequisites / notice

- Measure Theory
- Basic notions in probability theory (probability space, conditional probability, Borel Cantelli, Dynkin Lemma, random variables, expectation, variance, law of large numbers).

Competencies

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Creative Thinking

401-3621-00L Fundamentals of Mathematical Statistics

Abstract

In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.

Objective

The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.

Competencies

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Creative Thinking

401-7851-00L Theoretical Astrophysics (University of Zurich)

Abstract

This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Content

This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

Literature

- Course Materials:
  1- The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
  2- The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
  3- Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
  4- Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
  5- Galactic Dynamics, James Binney and Scott Tremaine

Prerequisites / notice

This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

- Prerequisites:
  - Introduction to Astrophysics
  - Mathematical Methods for the Physicist
  - Quantum Mechanics
  - Prior Knowledge: Mechanics
  - Quantum Mechanics and atomic physics
  - Thermodynamics
  - Fluid Dynamics
  - Electrodynamics

401-7855-00L Computational Astrophysics (University of Zurich)

Abstract

This course covers the foundations of computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes.

Objective

Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes.
<table>
<thead>
<tr>
<th><strong>Content</strong></th>
<th>Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large-N gravity calculation, collisionless N-body systems and their simulation</td>
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<tr>
<td></td>
<td>Fast Fourier Transform and spectral methods in general</td>
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<tr>
<td></td>
<td>Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters</td>
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<td>Lagrangian Hydrodynamics: The SPH method</td>
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<td>Resolution and instabilities in Hydrodynamics</td>
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<td></td>
<td>Initial Conditions: Cosmological Simulations and Astrophysical Disks</td>
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<tr>
<td></td>
<td>Physical Approximations and Methods for Radiative Transfer in Astrophysics</td>
</tr>
<tr>
<td><strong>Literature</strong></td>
<td>Galactic Dynamics (Binney &amp; Tremaine, Princeton University Press),</td>
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<td></td>
<td>Computer Simulation using Particles (Hockney &amp; Eastwood CRC press),</td>
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<td></td>
<td>Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)</td>
</tr>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Some knowledge of UNIX, scripting languages (see <a href="http://www.physik.uzh.ch/lectures/informatik/python/">www.physik.uzh.ch/lectures/informatik/python/</a> as an example), some prior experience programming, knowledge of C, C++ beneficial</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>402-6394-00L</strong></th>
<th>Advanced Topics of Theoretical Cosmology (University of Zurich)</th>
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</thead>
<tbody>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Prerequisite: 402-0394-00L Theoretical Astrophysics and Cosmology</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The course will cover a selection of advanced topics:</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>- Hamiltonian formulation of general relativity</td>
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<td>- Quantum cosmology</td>
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<td>- Cosmic Microwave Background</td>
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<td>- Dark Matter and Dark Energy</td>
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<td>- Nonlinear structure formation</td>
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<td>- Galaxy clustering and large-scale structure</td>
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<td></td>
<td>- Model selection and Bayesian inference in cosmology</td>
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<tr>
<td><strong>Competencies</strong></td>
<td>Subject-specific Competencies</td>
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</tbody>
</table>

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<tr>
<th><strong>402-0831-67L</strong></th>
<th>Advanced Topics in General Relativity and Gravitational Waves (University of Zurich)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Prerequisite: 402-0810-70L Advanced Quantum Algorithms (University of Zurich)</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The aim of this lecture is to discuss some advanced topics in general relativity, which are useful to understand the present research activities in the field. A list of possible topics is given below. A basic knowledge of general relativity is required (ideally having followed the lecture on General Relativity). The course is particularly suited for master and PhD students.</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Is to be able to read and understand the original literature and the presently published papers in the field of the discussed advanced topics. This might be also useful in view of doing afterwards a master thesis in the field of general relativity.</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Possible content:</td>
</tr>
<tr>
<td></td>
<td>- General relativistic stellar structure equations (Neutron stars)</td>
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<tr>
<td></td>
<td>- Tetrad formalism</td>
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<tr>
<td></td>
<td>- Spinors in GR</td>
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<tr>
<td></td>
<td>- Klein-Gordon &amp; Dirac eqs. in GR</td>
</tr>
<tr>
<td></td>
<td>- Thermodynamics of black holes and Hawking radiation</td>
</tr>
<tr>
<td></td>
<td>- Topics in gravitational waves: GW generation by PN sources, GW from elliptic, hyperbolic binaries</td>
</tr>
<tr>
<td></td>
<td>- Tests of the equivalence principle</td>
</tr>
<tr>
<td><strong>Competencies</strong></td>
<td>Subject-specific Competencies</td>
</tr>
<tr>
<td><strong>402-0810-70L</strong></td>
<td>Advanced Quantum Algorithms (University of Zurich)</td>
</tr>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Prerequisite: 402-0810-70L Advanced Quantum Algorithms (University of Zurich)</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The course treats selected families of quantum algorithms, currently the best candidates to achieve a practical quantum advantage over classical computation in physics, chemistry, optimization, sampling and machine learning. Starting from the basics, quantum algorithms are introduced and their feasibility to solve real-world problems in science and industry is critically discussed.</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>The course aims to provide a balanced outlook of this transformative technology, discussing strengths and possible limitations of all discussed algorithms, especially in the context of concrete today and future hardware implementation. After the course, students will have a clear understanding of the state-of-the-art of this field (i.e., the applications and algorithms amenable to quantum speedup, types of hardware, and quantum software). The course content is devised to provide first-hand experience with quantum algorithms and stimulate critical thinking. The course will be instrumental for the student's career development in quantum technology and computational science, in academia or industry.</td>
</tr>
</tbody>
</table>
The objective of the course is to familiarize the student with selected techniques from differential geometry and algebraic topology, and with geometric and topological methods employed in theoretical physics.

Prior knowledge in quantum information science is beneficial but not required. Knowledge of basic statistical mechanics and quantum mechanics is required, specifically: linear algebra, spin operators, many-body wavefunctions, Hamiltonians in second quantisation formalism.

In this course, we will set a performative frame for experimentation and exploration.

The covered mathematical topics include: homotopy groups, singular homology, Morse theory, Riemannian geometry, vector bundles, parallel transport, characteristic classes, cohomology theory, and Clifford algebras.

The applications to condensed matter physics include: defects of order parameters, Van Hove singularities, flat energy bands, topological band theory, gauge fields, tensor network classification, and topologically ordered states.

In this course, we will set a performative frame for experimentation and exploration.

### General Electives

**Students may choose General Electives from the entire course programme of ETH Zurich - with the following restrictions: courses that belong to the first or second year of a Bachelor curriculum at ETH Zurich as well as courses from GESS "Science in Perspective" are not eligible here.**
The following courses are explicitly recommended to physics students by their lecturers. (Courses in this list may be assigned to the category "General Electives" directly in myStudies. For the category assignment of other eligible courses keep the choice "no category" and take contact with the Study Administration (www.phys.ethz.ch/studies/application/deadline.html) after having received the credits.)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0579-24L</td>
<td>Understanding Light</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Barba, P. Anantha Murthy</td>
</tr>
</tbody>
</table>

**Abstract**
The seminar explores light from the perspectives of Physics and Art, opening up new dimensions for collaboration across disciplines by tackling questions such as: What is the origin and nature of light? How does it travel through space and time? How can it be made productive in an artistic sense and what, in turn, can artistic methodologies contribute to experimenting and thinking about light?

**Objective**
- Learn about the properties of light: intensities, phases, colors, and interactions with matter
- Learning the use of optics: reflection, refraction, dispersion
- Learning to plan and carry out an art project based on research inputs from other sciences
- Enhancing conceptual and interdisciplinary thinking in unusual set-ups
- Learn how to cope with unforeseen results and make random events productive for the successful implementation of a project
- Fostering communication and presentation skills

**Content**
Coupled with experiments in the Dep. of Physics, students will be introduced to concepts such as the origin of light and color, and the interpretation of the optical world that surrounds us to understand what actually gives rise to the effects we see everyday—from butterfly wings and autumn colors to the appearance of buildings and cities. In addition, we will perform practical experiments with basic optical components like lenses, mirrors, and prisms, in order to understand how they can be used to capture images. Inputs by guest lecturers (e.g. on light in photography, anthropology or urban landscapes) are planned. Students will be asked to present related topics.

At the end of the semester, the artistic experiments will be presented.

**Prerequisites / notice**
Max. number of participants: 15

Please send a short motivation letter (max. 300 words) to artinspaceandtime@arch.ethz.ch by 05 September 2024.
Renewable Energy Technologies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Objective
Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Methods
- Lecture Notes containing copies of the presented slides.
- Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

Literature

Competencies
- Subject-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Communication
- Teamwork

Personal Competencies
- Critical Thinking

Nuclear Energy Conversion

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Critical Thinking

Objective
Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding.

Methods
- Hand-outs will be distributed. Additional literature and information on the website of the lab: https://www.ethz.ch/content/specialinterest/mavt/energy/technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00l-nuclear-energy-conversion.html
- Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

Literature
- R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

Nonlinear Dynamics and Chaos I

Subject-specific Competencies
- Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Methods
- The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

Embedded MEMS Lab

Subject-specific Competencies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Objective
Students learn the individual process steps that are required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report.

Methods
- Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report.
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

Literature
- C. Hierold, A. Günther, M. Halusa
Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods are being used in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.

The course builds upon three parts:
1. Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
2. Theoretical basis of statistical mechanics and kinetic equations.

The content of the course includes:
1. Background: Elements of statistical mechanics and kinetic theory:
   - Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation.
   - Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.
2. Basics of the Lattice Boltzmann Method and Simulations:
   - Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.
3. Hands on:
   - Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).
4. Practical issues of LBM for fluid dynamics simulations:
   - Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.
5. Microflow:
   - Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.
6. Advanced lattice Boltzmann methods:
   - Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.
7. Introduction to LB models beyond hydrodynamics:
   - Relativistic fluid dynamics; flows with phase transitions.

Lecture notes on the theoretical parts of the course will be made available. Selected original and review papers are provided for some of the lectures on advanced topics. Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.
Objective

Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps ( = process flow).

Content

- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

Application of selected technologies will be demonstrated on case studies.

Lecture notes

Handouts (available online)

Literature

- S. M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O. Paul: Microsystem Technology
- Hong Xiao: Introduction to Semicondutor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites / notice

Prerequisites: Physics I and II

227-0385-10L Biomedical Imaging W 6 credits 5G S. Kozerke, K. P. Prüssmann

Abstract

Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective

Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Content

- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

Lecture notes

Lecture notes and handouts

Literature

Webb A, Smith N. B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

227-0386-00L Biomedical Engineering W 4 credits 3G J. Várös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content

- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Biomechanics.
- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.
Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

227-1047-00L Consciousness: From Philosophy to Neuroscience (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI410

Abstract
This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective features of consciousness are explored, and modern research into its neural substrate, particularly in the visual domain, is explained.

Objective
The course's goal is to give an overview of the contemporary state of consciousness research, with emphasis on the contributions brought by modern cognitive neuroscience. We aim to clarify concepts, explain their philosophical and scientific backgrounds, and to present experimental protocols that shed light on on a variety of consciousness related issues.

Content
The course includes discussions of scientific as well as philosophical articles. We review current schools of thought, models of consciousness, and proposals for the neural correlate of consciousness (NCC).

Lecture notes
None

Literature
We display articles pertaining to the issues we cover in the class on the course's webpage.

Prerequisites / notice
Since we are all experts on consciousness, we expect active participation and discussions!

227-0939-00L Cell Biophysics

Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective
Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life's mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental results from the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.
Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns

Lecture notes

Theory and corresponding exercises are merged together during the classes.

I am willingly available Mondays 17.00 o'clock - 18.00 in my office GLC F12.2 for whatever discussion about the lessons and the exercises.

I am using OneNote. All lectures will be broadcast via ZOOM, while corresponding videos of the previous years (lectures and exercises) are available in Moodle.

Literature


As further deepening:

Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies fostered

Method-specific Competencies

- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management assessed

Social Competencies

- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity assessed
- Negotiation fostered

Personal Competencies

- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

227-0423-00L  Neural Network Theory

Does not take place this semester.

Abstract

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

Content

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

Lecture notes

Detailed lecture notes are available on the course web page
https://www.mins.ee.ethz.ch/teaching/nnt/
The measurement process is at the heart of both science and engineering. Measurement precision is ultimately limited by the laws of quantum mechanics. This course provides the knowledge necessary to understand current state-of-the-art quantum measurement systems operating at their fundamental limits with a particular focus on optomechanical implementations.

The goal of this course is to understand the quantum limits of measurement precision together with a formal description of the measurement process in the framework of quantum mechanics.

The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. We discuss the "standard quantum limit" as it arises from the balance of measurement imprecision and backaction, before turning to approaches to overcome it and reach the fundamental "Heisenberg limit". The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics. Exercises serve to consolidate our understanding and insight.

Prerequisites / notice

1. Electrodynamics
2. Physics 1,2
3. Introduction to quantum mechanics

Competencies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies

Communication
Cooperation and Teamwork

Personal Competencies

Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

227-0965-00L Micro and Nano-Tomography of Biological Tissues

Abstract

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morpometry and statistics.

Objective

Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morpometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes

Available online

Literature

Will be indicated during the lecture.

227-0157-00L Semiconductor Devices: Physical Bases and Simulation

Abstract

The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

Objective

The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

Content

The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (inntrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

Lecture notes

The script (in book style) can be downloaded from: https://iis-students.ee.ethz.ch/lectures/

Literature

The script (in book style) is sufficient. Further reading will be recommended in the lecture.

Prerequisites / notice


227-0147-10L VLSI 3: Full-Custom Digital Circuit Design

Abstract

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.
Objective: At the end of this course, you will

- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

Content: The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.


Prerequisites:

- VLSI 1: HDL Based Design for FPGAs
- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies:
- Analytical Competencies
- Problem-solving

Competencies:

- Subject-specific Competencies
- Method-specific Competencies

Prerequisites:

- VLSI 3 can be taken in parallel with "VLSI 1: HDL-based design for FPGAs" and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

Subject-specific Competencies:

- Analytical Competencies
- Problem-solving

Method-specific Competencies:

- Analytical Competencies
- Problem-solving

227-0116-00L

VLSI 1: HDL Based Design for FPGAs

W 6 credits 5G F. K. Gürkaynak

Objective: Understand Very-Large-Scale Integrated Circuits (VLSI) chips, Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content: This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:

- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Aneurdiagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.


Problem-solving

Techniques and Technologies

Abstract: This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Lecture notes:

- Textbook and all further documents in English.

Prerequisites:

- Basics of digital circuits.
- Exam:
  - In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:

https://itis-students.ee.ethz.ch/lectures/vlsi-i/

227-0301-00L

Optical Communication Fundamentals

W 6 credits 2V+1U+1P J. Leuthold

Objective: An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

Abstract: The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and electronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

- Full-custom accelerator circuits for machine learning
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
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During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.
This course focuses on the current state and prospects of memory technologies, emerging beyond the silicon transistor era. We explore the leading contenders for post-silicon storage-class and main memory technologies. Decades of research have yielded several efficient memory device working principles, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM, MTJ), and ferroelectricity (FRAM, FeFET). Currently, these memory technologies are transitioning from research to industry, and are predicted to have at least niche applications in the ever-growing hardware market. Some technologies, such as PCM, may even eventually surpass silicon-based flash memory, providing better performance and unique features.

Students will have the opportunity to compare emerging memory technologies with state-of-the-art SSD Flash, DRAM, and SRAM, as well as evaluate their potential. Through critical thinking discussions, students will acquire important skills for assessing the strengths and limitations of these emerging technologies.

The course will cover the following carbon-based materials:
- Carbon nanotubes
- Graphene nanoribbons
- Graphene (single layer, bilayer, twisted bilayer)
- Single-molecule
- Carbon nanotubes
- Graphene

For each material, we will discuss:
- Electronic structure and charge transport properties
- Material synthesis and characterization
- Device integration and characterization

The course also includes a presentation by each student in which a related scientific publication is discussed. This presentation will be assessed as evaluate their potential. Through critical thinking discussions, students will acquire important skills for assessing the strengths and limitations of these emerging technologies.

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Literature
Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010
M. Yarema

Abstract
This course focuses on the current state and prospects of memory technologies, emerging beyond the silicon transistor era. We explore the leading contenders for post-silicon storage-class and main memory technologies. Decades of research have yielded several efficient memory device working principles, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM, MTJ), and ferroelectricity (FRAM, FeFET). Currently, these memory technologies are transitioning from research to industry, and are predicted to have at least niche applications in the ever-growing hardware market. Some technologies, such as PCM, may even eventually surpass silicon-based flash memory, providing better performance and unique features.

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Nano-Optics

Abstract
Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Objective
Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

Content
We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

Prerequisites / notice
- Electromagnetic fields and waves (or equivalent)
- Physics I+II

Nanodevices and Circuits for the Beyond-Moore Era

Abstract
Big Data, AI and the Internet of Things demand new hardware which overcomes the limitations of von Neumann architectures. The lecture gives an insight how the fundamental physics and the resulting complex functionalities of nanodevices and circuits offer viable alternatives. Their increased computational power and energy efficiency are demonstrated through neuromorphic computing applications.

Objective
The students will gain a firm understanding in the theory and pioneering experiments of electronic and heat transport at atomic- to nanometer length-scales. Advanced device functionalities enabled by recently discovered material systems will be covered. The students will learn how to exploit such phenomena for designing nanodevices and circuits to energy-efficiently implement neuromorphic algorithms for a sustainable future of information technologies.

Lecture notes
The presentation slides and further material will be provided every week.

Prerequisites / notice
Basic knowledge of solid state physics and semiconductors.

Information Systems for Engineers

Abstract
This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content
Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

Literature
- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice
- Elementary knowledge of set theory and logics
- Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
- The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only, BSc and MSc
Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking

Electron Microscopy in Material Science

Abstract
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective
A comprehensive understanding of the interaction of electrons and ions with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content
This course provides a general introduction into electron- and ion- microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, focused ion-beam and atom probe microscopes are presented. Throughout the semester, various applications in materials science, solid state physics, structural biology, structural geology, and structural chemistry will be reported.

Lecture notes
will be distributed in English

Literature
- Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

327-0702-00L EM-Practical Course in Materials Science

Abstract
Practical work on TEM, SEM, FIB and APT treatment of typical problems

data analysis, writing of a report

Objective
Application of basic electron microscopic techniques to materials science problems

Literature
see lecture Electron Microscopy (327-0703-00L)

Prerequisites / notice
Attendance of lecture Electron Microscopy (327-0703-00L) is recommended.

Maximum number of participants 15, work in groups of 3 people.

Microscopy Training SEM I - Introduction to SEM

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP.html).

All applicants must additionally register on this form:
https://docs.google.com/forms/d/1Xw8L_2yXTE9qXxW9C

c6mjKMVqdVxSUeJEd--9CwDXXk0/edit

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.
### Content
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

- Lectures:
  - Introduction on Electron Microscopy and instrumentation
  - electron sources, electron lenses and probe formation
  - beam/specimen interaction, image formation, image contrast and imaging modes.
  - sample preparation techniques for EM
  - X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

- Practicals:
  - Brief description and demonstration of the SEM microscope
  - Practice on image formation, image contrast (and image processing)
  - Student participation on sample preparation techniques
  - Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
  - Practice on real-world samples and report results

### Literature

### Prerequisites / notice
No mandatory prerequisites.

### 327-2126-00L Microscopy Training TEM I - Introduction to TEM

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All applicants must additionally register on this form: https://docs.google.com/forms/d/1nrDTHjPyScB7Xk2qZiNxPwFW7Wv6EMJ9carEAQz8/edit

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

### Abstract
The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

### Objective
Understanding of
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

### Content
- Lectures:
  - basics of electron optics and the TEM instrument set-up
  - TEM imaging modes and image contrast
  - STEM operation mode
  - Sample preparation techniques for hard and soft materials

- Practicals:
  - Demo, practical demonstration of a TEM: instrument components, alignment, etc.
  - Hands-on training for students: sample loading, instrument alignment and data acquisition.
  - Sample preparation for different types of materials
  - Practical work with TEMs
  - Demonstration of advanced Transmission Electron Microscopy techniques

### Literature

### Prerequisites / notice
No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

### 327-2210-00L Thin Films Technology - From Fundamentals to Oxide Electronics

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<td>W</td>
<td>Students who already took &quot;327-2104-00L Inorganic Thin Films: Processing, Properties and Applications&quot; AND &quot;327-2132-00 Multifunctional Ferroic Materials: Growth and Characterisation&quot; are not allowed to attend this course.</td>
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**Abstract**
Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal.

We will give an introduction to thin films deposition techniques and applications with a focus on the growth of multifunctional oxide thin films.
In this course students will obtain an overarching view on thin film deposition techniques with a focus on epitaxial deposition processes. The main learning objectives are:

- Identification of most relevant deposition technique for a given application.
- Understanding of growth mechanism and growth modes.
- Understanding strategies for engineering the functionalities of the films using the deposition process.
- Selection of the most appropriate characterization technique.
- Understanding device concepts and fundamental limits in the technology relevant ultra-thin limit.
- Assessing the relevance of scientific literature dealing with complex oxide thin films.

Content

A lab visit will be organized and students will participate to the design of thin films with atomic precision.

General description of the leading deposition routes including physical and chemical vapor deposition techniques (PVD and CVD) as well as so called “wet techniques” (e.g. spin coating and spray pyrolysis).

Growth modes and processes.

Part of the course discusses vacuum technologies.

Fundamental characterization techniques for application-relevant thin films as well as state of the art approaches for in situ and ex-situ determination of the structural, chemical and ferroic (ferromagnetic and ferroelectric) properties of films: (XRD for thin films, RHEED, EDX, scanning probe microscopy techniques, laser-optical characterization and many more)

Epitaxy for the advanced design and characterization of high quality thin films for energy efficient oxide electronics.

Types of ferroic order, multiferroics, multifunctional oxide materials, epitaxial strain related effects, oxide thin film based devices and examples.

Regular discussions on preselected scientific literature and mini-seminars will be organized.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

363-0537-00L Resource and Environmental Economics W 3 credits 2G A. Miftakhova. A. Minabutdinov

Abstract

Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

Objective

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature


Education

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. The following topics will be:

- **Analytical Competencies**
  - Concepts and Theories
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Communication
  - Cooperation and Teamwork
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection

- **Creative Thinking**
  - System theory sees the economy as a complex adaptive system.

- **System theory**
  - Economic Dynamics and Complexity
  - DNP theory & instrumentation
  - Microwave theory & technology

- **Social Competencies**
  - Self-awareness and Self-reflection
  - Integrity and Work Ethics
  - Communication
  - Cooperation and Teamwork
  - Critical Thinking
  - Decision-making
  - Problem-solving
  - Analytical Competencies
  - Concepts and Theories

The course aims at enabling students to understand the key theoretical points of DNP and to design DNP experiments. Students will be familiarized with the structure of the state-of-the-art DNP instrumentation. Students will be also informed about the technological challenges towards the development of advanced instrumentation for the future DNP experiments. A special focus will be given in the technology of microwave source.

Furthermore, students will become familiar with pulse sequences used in biomolecular applications and understand how they are constructed. Students will be able to identify the strengths and weaknesses of biomolecular DNP and how to design DNP experiments for biological applications including sample preparation and choice of NMR experiment and related parameters.

The first part will cover DNP concept and mechanisms, while a special focus will be given in DNP instrumentation, such as MAS spectroscopy. A special focus will be given in the technology of microwave source and applications.

The second part of the course is dedicated to the microwave theory and technology. This part starts with an introduction of the two different types of microwave sources, such as the solid-state devices and vacuum tubes, which are extensively used in DNP and EPR spectroscopy. A special focus will be given to the vacuum tube's theory and technology. In this context, the Maxwell equations and the propagation of the transverse electric and transverse magnetic modes in circular waveguides will be taught. This material will be the basis for understanding the resonance theory and the fundamentals of the microwave's generation in vacuum tubes. Based on the theoretical background gained in the previous lectures it will be possible to understand the operation principle of the slow wave devices, such as Klystron, Traveling Wave Tube (TWT), Backward Wave Oscillator (BWO) and Surface Wave Structure (SWS), as well as, the fast wave devices, such as gyro-devices, Free Electron Laser, etc. Finally, some details on the structure of a real DNP gyrotron will be presented.

The third part of the course will cover CPMAS and homonuclear and heteronuclear recoupling schemes and their use in correlation spectroscopy for structure and molecular interaction. Sample preparation with particular emphasis of glassing agents and their relationship to DNP enhancements will be discussed. Resolution under DNP including a discussion about inhomogeneous and homogeneous broadening at cryogenic temperatures. Methods for circumventing low resolution at cryogenic temperatures will be discussed including site specific isotope labeling, bio-orthogonal labeling and site specific radical labeling/targeting. Concepts around the role of spin diffusion in DNP, direct and indirect DNP, paramagnetic broadening, longitudinal T1 and methyl quenching in biological NMR will also be discussed. These concepts will then be tied together through discussions of biomolecular applications of solid-state DNP including membrane proteins, in-cell DNP and viruses.
Advanced Magnetic Resonance - Biological Magnetic Resonance

Abstract
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. It is concerned with inference of structure and dynamics of proteins and their complexes from data obtained by EPR and liquid-state NMR experiments. The special focus is on multi-state and ensemble modelling.

Objective
This course enables students to design experimental strategies for characterization of structure and dynamics of proteins whose flexibility is relevant for their function. Students understand the spin dynamics that encodes sidechain and backbone motion as well as distance information into signals measured by magnetic resonance experiments. They learn to solve the inverse problem of inferring dynamics parameters and distances from the experimental results. They acquire skills in modelling protein ensemble structure from constraints derived by analyzing magnetic resonance data. Students are aware of the complications introduced by the use of spin labels in such experiments and learn how to include such labels in modelling.

Content
- Nitrooxide spin labels, their interaction with the environment, and influence of their dynamics on EPR line shapes
- Contributions to electron spin decoherence and ways to improve resolution in pulsed EPR
- Measurement of electron-electron dipole-dipole interaction and conversion of the primary data to distance distributions
- Modelling of spin labels by rotor libraries
- Ensemble modelling with distance distributions
- Liquid-state NMR experiments for assessing protein structure and dynamics
- Assignment of NMR signals for proteins
- Theory of the nuclear Overhauser effect (NOE)
- Ensemble modelling with exact NOE constraints
- Multistate structure calculation and analysis
- Further constraints on protein structure and dynamics from NMR experiments

Lecture notes
A script, which covers the topics, will be accessible through the course Moodle.

Prerequisites / notice
A basic knowledge of magnetic resonance, e.g. as covered in the lecture course Physical Chemistry IV or in the book "Spin Dynamics" by Malcolm Levitt

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

Advanced Magnetic Resonance - Solid State NMR

Does not take place this semester.

Advanced Physical Chemistry: Statistical Thermodynamics

Abstract

Objective
The aim of the course is to familiarize the students with the basic concepts of modern high-resolution solid-state NMR. Starting from the mathematical description of spin dynamics, important building blocks for multi-dimensional experiments are discussed to allow students a better understanding of modern solid-state NMR experiments. Particular emphasis is given to achieving high spectral resolution.

Content
The basic principles of NMR in solids will be introduced. After the discussion of basic tools to describe NMR experiments, basic methods and experiments will be discussed, e.g., magic-angle spinning, cross polarization, decoupling, and recoupling experiments. Such basic building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

Lecture notes
A script which covers the topics will be distributed in the lecture and will be accessible through the web page http://www.ssnmr.ethz.ch/education/

Prerequisites / notice
Prerequisite: A basic knowledge of NMR, e.g. as covered in the Lecture Physical Chemistry IV, or the book by Malcolm Levitt.

Competencies

Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed

Social Competencies
Communication fostered

Personal Competencies
Creative Thinking assessed

Geophysics III

Abstract
This course builds on Geophysik I and Geophysik II, broadening the students' education in seismology, geodynamics and geodynamics theory, by considering various specific topics of particular interest.

Objective
To teach students the basics of observational seismology, earthquake source seismology, seismotectonics and the principle of seismic tomography, mantle convection over Earth history, structure of the oceanic and continental lithosphere, plate tectonics, hotspots, global heat flux, dynamo operation and magnetic field generation in Earth, planets, the Sun and stars and electromagnetism to probe the mantle.
Content
Observational seismology, earthquake source seismology, seismotectonics and the principle of seismic tomography. Mantle convection over Earth history, structure of the oceanic and continental lithosphere, plate tectonics, hotspots, global heat flux. Dynamo operation and magnetic field generation in Earth, planets, the Sun and stars; electromagnetism to probe the mantle.

651-4010-00L Planetary Sciences: a Physical Perspective W 3 credits 2G C. Gillmann

Abstract
This course aims to give a physical understanding of the formation, structure, dynamics and evolution of planetary bodies in our solar system and also apply it to ongoing discoveries regarding planets around other stars.

Objective
The goal of this course is to enable students to understand current knowledge and uncertainties regarding the formation, structure, dynamics and evolution of planets and moons in our solar system, as well as ongoing discoveries regarding planets around other stars. Students will practice making quantitative calculations relevant to various aspects of these topics through weekly homeworks.

The main topics covered are: Orbital dynamics and Tides, Solar heating and Energy transport, Planetary atmospheres, Planetary surfaces, Planetary interiors, Asteroids and Meteorites, Comets, Planetary rings, Magnetic fields and Magnetospheres, The Sun and Stars, Planetary formation, Exoplanets and Exobiology

Lecture notes
Slides and scripts will be posted on Moodle.

Literature
It is recommended but not mandatory to buy one of these books:


Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered

Personal Competencies
Adaptability and Flexibility fostered

701-1257-00L European Climate Change W 3 credits 2G E. Fischer, J. Rajczak, S. C. Scherrer

Abstract
The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:

• observational datasets, observation and detection of climate change;
• underlying physical processes and feedbacks;
• numerical and statistical approaches;
• currently available projections.

Objective
At the end of this course, participants should:

• understand the key physical processes shaping climate change in Europe;
• know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
• be familiar with relevant observational and modeling data sets;
• be able to tackle simple climate change questions using available data sets.

Content
Contents:
• global context
• observational data sets, analysis of climate trends and climate variability in Europe
• global and regional climate modeling
• statistical downscaling
• key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects

Lecture notes
Slides and lecture notes will be made available at http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html

Prerequisites / notice
Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

Proseminars and Semester Papers
Detailed information at: https://www.phys.ethz.ch/studies/master/semester-projects.html

Bachelor students in Physics who wish to register for a MSc Semester Project or Proseminar need to contact the study administration (studiensekretariat@phys.ethz.ch).

Number Title Type ECTS Hours Lecturers
402-0218-MSL Research Project W 8 credits 15A Supervisors

Abstract
Students conduct a small research project within a research group or carry out a guided self-study of original papers on a given theoretical topic. The results are submitted in a written report and an oral presentation.

Objective
Students are enabled to:
• expand their knowledge in a specific area of physics,
• conduct a project (a) in a research laboratory or (b) on a specific topic of theoretical physics,
• discuss their project results and conclusions in a team,
• present their findings in written and oral form.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking fostered
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

402-0219-MSL Research Project II
To register, please contact the study administration at studies.physics@ethz.ch

Abstract
Students conduct a small research project within a research group or carry out a guided self-study of original papers on a given theoretical topic. The results are submitted in a written report and an oral presentation.

Objective
Students are enabled to:
• expand their knowledge in a specific area of physics,
• conduct a project (a) in a research laboratory or (b) on a specific topic of theoretical physics,
• discuss their project results and conclusions in a team,
• present their findings in written and oral form.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking fostered
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-PHYS

Master's Thesis

Number Title Type ECTS Hours Lecturers
402-0900-30L Master's Thesis O 30 credits 57D Supervisors

402-0200-00L Scientific Works in Physics O 0 credits D. Kienzler

Target audience:
Master students who cannot document to have received an adequate training in working scientifically.

Directive

Abstract
Literature Review: ETh-Library, Journals in Physics, Google Scholar; Thesis Structure: The IMRAD Model; Document Processing: LaTeX and BibTeX, Mathematical Writing, AVETH Survival Guide; ETH Guidelines for Integrity; Authorship Guidelines; ETH Citation Etiquettes; Declaration of Originality.

Objective
Basic standards for scientific works in physics: How to write a Master Thesis. What to know about research integrity.
The Master's thesis concludes the Master's programme and constitutes a full-time project of six-month duration aimed at advancing the skills and capabilities of students to work independently and creatively towards the solution of an individual research problem which has been agreed upon in advance.

Objective
Students are enabled to:
- solve a complex problem by applying theoretical and experimental methods and skills,
- articulate their beliefs and thoughts on a scientific subject, appreciate the positions of others and revisit their own positions based on new insights,
- contribute constructively to the projects of a diverse research team,
- actively participate in a scientific discourse on a specific area of physics and present positions based on scientific arguments.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Seminars, Colloquia, and Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
</tr>
<tr>
<td>402-0800-00L</td>
<td>The Zurich Theoretical Physics Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>J. Renes, University lecturers</td>
</tr>
<tr>
<td>401-5330-00L</td>
<td>Talks in Mathematical Physics</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>M. Gaberdiel, G. M. Graf, T. H. Willwacher</td>
</tr>
<tr>
<td>402-0551-00L</td>
<td>Laser Seminar</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>T. Esslinger, J. Faist, J. Home, A. Imamoglu, F. Merkt, H. J. Wörner</td>
</tr>
<tr>
<td>402-0600-00L</td>
<td>Nuclear and Particle Physics with Applications</td>
<td>E-</td>
<td>0</td>
<td>2S</td>
<td>A. Rubbia, K. S. Kirch, R. Wallny</td>
</tr>
<tr>
<td>402-0893-00L</td>
<td>Particle Physics Seminar</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>T. K. Gehrmann</td>
</tr>
<tr>
<td>402-0700-00L</td>
<td>Seminar in Elementary Particle Physics</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>M. Spira</td>
</tr>
<tr>
<td>402-0746-00L</td>
<td>Seminar: Particle and Astrophysics (Aktuelles aus der E-</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>University lecturers</td>
</tr>
<tr>
<td>402-0300-00L</td>
<td>IPA Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>A. Biland, A. de Costa, A. Refregier, further lecturers</td>
</tr>
<tr>
<td>402-0396-00L</td>
<td>Recent Research Highlights in Astrophysics</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Autumn Semester 2024
(University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: AST006

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

402-0530-00L Mesoscopic Systems E- 0 credits 1S T. M. Ihn

Objective

Research colloquium

Students are able to understand modern experiments in the field of mesoscopic systems and nanostructures. They can present their own results, critically reflect published research in this field, explain both to an audience of physicists, and participate in a critical and constructive scientific discussion.

402-0620-00L Current Topics in Accelerator Mass Spectrometry and Its Applicatons E- 0 credits 2S M. Christl, S. Willett

Objective

The seminar is aimed at all students who, during their studies, are confronted with age determination methods based on long-living radionuclides found in nature. Basic methodology, the latest developments, and special examples from a wide range of applications will be discussed.

402-1043-00L Neuroinformatics - Colloquia (University of Zurich) E- 0 credits 1K S.-C. Liu, R. Hahnloser, V. Mante

Objective

The colloquium in Neuroinformatics is a series of lectures given by invited experts. The lecture topics reflect the current themes in neurobiology and neuromorphic engineering that are relevant for our Institute.

Content

The topics depend heavily on the invited speakers, and thus change from week to week.

All topics concern neural computation and their implementation in biological or artificial systems.

651-1581-00L Seminar in Glaciology E- 3 credits 2S A. Bauder, M. Jacquemart

Objective

Introduction to classic and modern literature of research in Glaciology. Active participation is expected and participants are mentored by PhD students of Glaciology.

Content

In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection

Prerequisites / notice

Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:

- 651-3561-00L Kryosphäre
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers

402-0010-00L Basics of Computing Environments for Scientists Z 0 credits 1V C. D. Herzog, C. Becker, S. Müller

Objective

Enrollment is only possible under https://www.lehrbetrieb.ethz.ch/labopraktika

No registration required via myStudies.

Abstract

Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists.
Objective

The "IT at D-PHYS" introduction provides a good understanding of how IT works at D-PHYS and presents an overview of the IT services and their providers. It is recommended for everyone joining the department.

The "IT and Information Security" crash course will address the most common threats you'll encounter when using the internet and teach you how to fend them off.

The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges.

The "Linux Basics" modules offer an introduction to the Linux landscape and show how to work on the shell by using command line tools. The first part provides a basic understanding of Linux systems and their components. It introduces commands essential to working with local and remote machines. The second part focuses on more advanced tools and workflows and provides guidelines to scripting, automation and customization.

The "Python Ecosystem" modules present various aspects of the environment around Python. Without teaching the Python programming language itself, it aims at providing understanding of various concepts surrounding it. The first part focuses on getting ready to run code. It discusses the management of Python interpreters, packages and virtual environments. The second part presents tools for writing Python code and interacting with strings. From development environments (IDE, Jupyter), over code formatters and linters, to string formatting and parsing with regular expressions. The third part sits at the interface between Python code and external data files. We explain how to read or write files, discuss data types and file formats. We show how to handle configuration parameters and mention tools to automate the data analysis.

The "System Aspects module" deals with the hardware-related side of scientific computing. To get the best performance out of your scientific code, you have to be aware of the underlying hardware and adapt to it.

Use the dedicated web page https://www.lehrbetrieb.ethz.ch/laborpraktika to register. Enrolled students are eligible for an attestation of attendance after visiting at least 3 out of the 5 modules. Refer to https://compenv.phys.ethz.ch for the detailed contents.

Content

Introduction:

IT at D-PHYS (IT service providers and IT services at D-PHYS)
IT and Information Security

Modules:

- Linux Basics I (system components, basic shell usage)
- Linux Basics II (advanced tools, scripting)
- Python Ecosystem I (interpreters, packages, virtual environments)
- Python Ecosystem II (development environments, formatter and linter, string formatting, regexp)
- Python Ecosystem III (external data files, config parameters and automation)
- System Aspects (how the hardware affects your scientific code and vice versa)

Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies

Method-specific Competencies
- fostered
- fostered

Problem-solving
- fostered

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>406-0204-AAL</td>
<td>Electrodynamics</td>
<td>E-</td>
<td>7</td>
<td>15R</td>
<td>N. Beisert</td>
</tr>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Develop a physical understanding for static and dynamic phenomena related to (moving) charged objects and understand the structure of the classical field theory of electrodynamics (transverse versus longitudinal physics, invariances (Lorentz-, gauge-)). Appreciate the interrelation between electric, magnetic, and optical phenomena and the influence of media. Understand a set of classic electrodynamical phenomena and develop the ability to solve simple problems independently. Apply previously learned mathematical concepts (vector analysis, complete systems of functions, Green's functions, co- and contravariant coordinates, etc.). Prepare for quantum mechanics (eigenvalue problems, wave guides and cavities).</td>
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</tr>
<tr>
<td>Content</td>
<td>Classical field theory of electrodynamics: Derivation and discussion of Maxwell equations, starting from the static limit (electrostatics, magnetostatics, boundary value problems) in the vacuum and in media and subsequent generalization to the full dynamical case (Faraday's law, Ampere/Maxwell law; potentials and gauge invariance). Wave equation and solutions in full space, half-space (Snell's law), waveguides, cavities, generation of electromagnetic radiation, scattering and diffraction of light (optics). Application to various specific examples. Discussion of the structure of Maxwell's equations, Lorentz invariance, relativity theory and covariance, Lagrangian formulation. Dynamics of relativistic particles in the presence of fields and their radiation properties (synchrotron).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Literature   | J.D. Jackson. Classical Electrodynamics
|              | W.K.H Panovsky and M. Phillips. Classical electricity and magnetism
|              | A. Sommerfeld. Elektrodynamik, Optik (Vorlesungen über theoretische Physik)
|              | M. Born and E. Wolf. Principles of optics
|              | R. Feynman, R. Leighton, and M. Sands, The Feynman Lectures of Physics, Vol II |
| 401-2673-AAL | Numerical Methods for CSE            | E-     | 9    | 19R   | not available |
|              | Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit. |
| Abstract     | The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++. |

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2103 of 2667
**Objective**

- Knowledge of the fundamental algorithms in numerical mathematics
- Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
- Ability to choose the appropriate numerical method for concrete problems
- Ability to interpret numerical results
- Ability to implement numerical algorithms efficiently

**Content**

- Direct Methods for linear systems of equations
- Least Squares Techniques
- Data Interpolation and Fitting
- Filtering Algorithms
- Approximation of Functions
- Numerical Quadrature
- Iterative Methods for non-linear systems of equations

**Lecture notes**

Lecture materials (PDF documents and codes) will be made available to participants.

**Literature**


M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

**Prerequisites / notice**

Solid knowledge about fundamental concepts and techniques from linear algebra & calculus as taught in the first year of science and engineering curricula.

The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves.

**Physics Master - Key for Type**

<table>
<thead>
<tr>
<th>Z</th>
<th>Courses outside the curriculum</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Students in the Joint Degree Master's Programme "Quantitative Finance" must book University of Zurich modules directly at the University of Zurich. Those modules are not listed here.

**Core**

**FIN (Finance)**

For possible (additional) course offerings see www.msfinance.ch

**MF (Mathematical Methods in Finance)**

For possible additional course offerings see www.msfinance.ch

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4 credits</td>
<td>3V+2U</td>
<td>D. Possamaï</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>First introduction to main modelling ideas and mathematical tools from mathematical finance</td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.</td>
<td></td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>Topics to be covered include</td>
<td></td>
<td></td>
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<tr>
<td>- financial market models in finite discrete time</td>
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<tr>
<td>- absence of arbitrage and martingale measures</td>
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<tr>
<td>- valuation and hedging in complete markets</td>
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<tr>
<td>- basics about Brownian motion</td>
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<tr>
<td>- stochastic integration</td>
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<tr>
<td>- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem</td>
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</tr>
<tr>
<td>- Black-Scholes formula</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>See information on course homepage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Prerequisites: Results and facts from probability theory as in the book &quot;Probability Essentials&quot; by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course &quot;Wahrscheinlichkeits- theorie&quot;.)</td>
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<td>For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.</td>
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**Elective**

**FIN (Finance)**

For possible additional course offerings see www.msfinance.ch

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>401-4633-00L</td>
<td>Data Analytics in Organisations and Business</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>I. Flückiger</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>This lecture covers organizations and businesses' end-to-end data analytics process and deepens each process stage. It shows why a stage is needed and what actions are taken in each stage. It gives steps successfully applied in practice and loopholes when issues arise. Case studies from various industries will be presented for each stage.</td>
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<td><strong>Objective</strong></td>
<td>This course aims to give the students an understanding of the whole data analytics life cycle in the business world. It shows the expectations of companies and how it is measured. It enables the student to manage successfully all the non-methodological aspects of a data analytics project which are the primary source of failure in end-to-end executions. The student will become familiar with the &quot;business language, and cultural aspects of organizations. It also gives an overview of the data analytics tool, platform, and methods ecosystem for successful technical data analyses.</td>
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<td><strong>Content</strong></td>
<td>1) Introduction</td>
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<td>2) Framing the business problem</td>
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<td>4) Data</td>
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<td>5) Identification of problem-solving approaches and appropriate tools</td>
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<td>6) How to set up and validate models</td>
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<td>7) The deployment of a model</td>
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<td>8) Model lifecycle</td>
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<td>9) Operating models and roles</td>
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<td>10) Some words about soft skills needed by statistical and mathematical professionals</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>The lecture's presentation slides will be provided.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td>363-0711-00L</td>
<td>Accounting for Managers</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>H. Chen, to be announced</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>The course Accounting for Managers offers an introduction to financial and managerial accounting, especially for students who aspire for a career in business and management with a science or engineering background.</td>
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After attending the class, you should be able to:
- understand the accounting system, the reporting process, and be able to prepare financial statements
- feel comfortable reading and using the information presented in companies' annual reports
- understand cost concepts and conduct cost analyses
- become familiar with several classic decisions using managerial accounting information
- comment on the current events related to these topics

Accounting plays a critical role in the effective functioning of the financial market as well as the long-term success of a company. This course intends to provide an introduction to accounting for those who wish to pursue a career in business, and need the skills and knowledge to understand, analyze, and interpret accounting information to make informed decisions. The course is divided into two parts. In the first part, we focus on financial reporting and start with the basic accounting concepts and the accounting cycle, to learn how the financial system is set up in a company and how financial statements are prepared. We then delve deeper into each major account, and discuss how revenues and expenses are recognized, and how assets, liabilities, and equities are reported. In the second part, we focus on managerial accounting for internal managerial/operational decisions including fundamental topics such as cost behavior, cost estimation, CVP analyses, and relevant costing. We then cover budgeting and standard costing, which are important parts of accounting system in companies.

This course is a prerequisite for the course Financial Management.

No single textbook covers the course, below we list some useful references. Further materials will be made available to students prior to the lectures


Participants should have a basic understanding of financial management, gained, for example, from prior undergraduate economics, business, or accounting studies.

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<tr>
<th>Competencies</th>
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For possible additional course offerings see www.msfinance.ch

Number Title Type ECTS Hours Lecturers
401-3925-00L Non-Life Insurance: Mathematics and Statistics W 8 credits 4V+1U M. V. Wüthrich

Does not take place this semester.

The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.

The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.
The following topics are treated:

- Collective Risk Modeling
- Claim Counts Models
- Individual Claim Size Modeling
- Censoring and Truncation
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tarification
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

Lecture notes
- M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics
  http://ssrn.com/abstract=2319328

Literature
- M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications

Prerequisites / notice
This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.

Competencies

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| Method-specific Competencies | assessed | fostered |
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| Analytical Competencies      |          |
| Decision-making              |          |
| Media and Digital Technologies|        |
| Problem-solving              |          |
| Project Management           |          |

401-4889-00L Mathematical Finance

W 10 credits 4V+2U B. Acciaio

Abstract
- Advanced course on mathematical finance:
  - semimartingales and general stochastic integration
  - absence of arbitrage and martingale measures
  - fundamental theorem of asset pricing
  - option pricing and hedging
  - hedging duality
  - optimal investment problems
  - additional topics

Objective
- Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes)

Content
- This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- and probably others

Lecture notes
- The course is based on different parts from different books as well as on original research literature.

Lecture notes will not be available.

Literature
- While there are many textbooks on mathematical finance, none of them is ideal to cover the contents of this course. References include the following books:

Prerequisites / notice
- Prerequisites are the standard courses
  - Probability Theory (for which lecture notes are available)
  - Brownian Motion and Stochastic Calculus (for which lecture notes are available)

Those students who already attended "Introduction to Mathematical Finance" will have an advantage in terms of ideas and concepts.

This course is the second of a sequence of two courses on mathematical finance. The first course "Introduction to Mathematical Finance" (MF I), 401-3888-00, focuses on models in finite discrete time. It is advisable that the course MF I is taken prior to the present course, MF II.

For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imsl/education/education-in-stochastic-finance/overview-of-courses.html.
401-4657-00L Numerical Solution of Stochastic Ordinary Differential Equations

Abstract
This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective
The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content
Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes
There will be English, typed lecture notes for registered participants in the course.

Literature

Prerequisites / notice
Mandatory:
Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.

a) mandatory courses:
Measure - and Probability Theory I as covered in courses:
ETH 401-2283-00L Analysis III (Measure Theory)
UZH Kursmodul 10496 Hauptvorlesung: Mass- und Integrationstheorie

b) recommended courses:
Stochastic Processes I

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Leadership and Responsibility fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered
Investment returns are an important source of funding for social and pension insurance, and financial risk is an important threat to stability. We study short-term and long-term financial risk and its interplay with other risk factors, and we develop methods for the measurement and management of financial risk and return in an asset/liability context with the goal of ensuring sustainable funding.

Understand the basic asset-liability framework: essential principles and properties of social and pension insurance; cash flow matching, duration matching, valuation portfolio and loose coupling; the notion of financial risk; long-term vs. short-term risk; coherent measures of risk.

Understand the conditions for sustainable funding; derivation of required returns; interplay between return levels, contribution levels and other parameters; influence of guaranteed benefits.

Understand the notion of risk-taking capability: capital process as a random walk; measures of long-term risk and relation to capital; short-term solvency vs. long-term stability; effect of embedded options and guarantees; interplay between required return and risk-taking capability.

Be able to study empirical properties of financial assets: the Normal hypothesis and the deviations from it; statistical tools for investigating relevant risk and return properties of financial assets; time aggregation properties; be able to conduct analysis of real data for the most important asset classes.

Understand and be able to carry out portfolio construction: the concept of diversification; limitations to diversification; correlation breakdown; incorporation of constraints; sensitivities and shortcomings of optimized portfolios.

Understand and interpret the asset-liability interplay: the optimized portfolio in the asset-liability framework; short-term risk vs. long-term risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand and be able to address essential problems in asset/liability management, e.g. optimal risk/return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Have an overall view: see the big picture of what asset returns can and cannot contribute to social security; be aware of the most relevant outcomes; know the role of the actuary in the financial risk management process.

For pension insurance and other forms of social insurance, investment returns are an important source of funding. In order to earn these returns, substantial financial risks must be taken, and these risks represent an important threat to financial stability, in the long term and in the short term.

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of

1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

Extensive handouts will be provided. Moreover, practical examples and data sets in Excel will be made available.

Solid base knowledge of probability and statistics is indispensable. Specialized concepts from financial and insurance mathematics as well as quantitative risk management will be introduced in the lecture as needed, but some prior knowledge in some of these areas would be an advantage.

This course counts towards the diploma of "Aktuar SAV".

The exams ONLY take place during the official ETH examination period.

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401-3922-00L Life Insurance Mathematics 4 credits 2V M. Koller
Abstract The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides the most important terms such as mathematical reserves are introduced and calculated.

401-3915-73L Machine Learning in Finance and Insurance 5 credits 2V+1U P. Cheridito
This course introduces machine learning methods that can be used in finance and insurance applications.

**Objective**
The goal is to learn methods from machine learning that can be used in financial and insurance applications.

**Content**
Linear, polynomial, logistic, ridge and lasso regression, dimension reduction methods, singular value decomposition, kernel methods, support vector machines, classification and regression trees, random forests, XGBoost, neural networks, stochastic gradient descent, autoencoders, graph neural networks, transformers, credit analytics, pricing, hedging, insurance claim prediction.

**Lecture notes**
Course material is available on https://people.math.ethz.ch/~patrickc/mlf

**Literature**


**Prerequisites / notice**
The course requires basic knowledge in analysis, linear algebra, probability theory and statistics.

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**401-3931-00L Responsible Machine Learning with Insurance Applications**

**Abstract**
This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

**Objective**
The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

**Content**
- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

**Prerequisites / notice**
This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

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**401-5820-00L Seminar in Computational Finance for CSE**

**Prerequisites / notice**
Requirements: sound understanding of stochastic concepts and of concepts of mathematical Finance, ability to implement econometric or simulation routines in Python.

**Competencies**

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<tr>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
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<td>Negotiation</td>
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<tr>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<tr>
<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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</tbody>
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**Master's Thesis**
## Quantitative Finance Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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## Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Quantum Engineering Master

Core Courses
A minimum of 24 credits must be obtained from core courses during the MSc QE, course selection is subject to the tutor's agreement.

Quantum Technology Lab
This core course is a prerequisite for participation in the QuanTech Labs of the second and third semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
In this course students will be exposed to different topics of quantum engineering and develop ideas for possible projects. Based on presentations by ETH labs participating in the MSc QE program and with the assistance of a mentor students will work in groups to develop concrete plans for a quantum experiment.

Objective
Acquire a broad overview of quantum engineering activities at ETH and develop own ideas about future quantum engineering projects.

Engineering Core Courses
These core courses target students with a physics background and all those who need additional engineering foundations.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
</tbody>
</table>

Abstract
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Content

Literature

Prerequisites / notice
MATLAB is used for system analysis and simulation.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>F. K. Gürkaynak</td>
</tr>
</tbody>
</table>

Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modelling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

Lecture notes
During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Literature

Prerequisites / notice
Prerequisites: Basics of digital circuits.

Examination
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

Further details: https://iis-students.ee.ethz.ch/lectures/vlsi-i/
**Physics Core Courses**

These core courses target students with an engineering background and all those who need additional physics foundations.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0205-00L</td>
<td>Quantum Mechanics I</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U</td>
<td>M. Krstic Marinkovic</td>
</tr>
</tbody>
</table>

This course covers the basics of quantum mechanics, including topics such as quantum states, wave mechanics, and applications in technology.

**Abstract**
General structure of quantum theory: Hilbert spaces, states and observables, equations of motion, Heisenberg uncertainty relation, symmetries, angular momentum addition, EPR paradox, Schrödinger and Heisenberg pictures.

**Objective**
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

**Content**
The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.

**Lecture notes**
Auf Moodle

**Literature**
G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai, Modern Quantum Mechanics
A. Messiah, Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics
This course is an introduction to the physics of quantum mechanics following an information-theoretical approach. We start from the basic postulates, study the behaviour of quantum systems from a single spin to entangled particles in space, and connect the learnings to groundbreaking experiments from the past and the present. This course is well-suited for students with little background in physics.

Objective
This course teaches the basics of quantum physics, and complements courses in quantum computation and information theory. Students are equipped with tools to tackle complex quantum mechanical problems and foundational questions. The course covers approximately the same content as QM1, but from an information-driven perspective.

Content
Quantum formalism, from qubits to particles in space; Time and dynamics for quantum systems; Problems in 1D; Uncertainty and open systems; Spin; Problems in 3D; Non-locality and foundational aspects of quantum theory

Lecture notes
Lecture notes will be provided.

Literature
Quantum Processes Systems, and Information, by Benjamin Schumacher and Michael Westmoreland, available at
https://www.cambridge.org/core/books/quantum-processes-systems-and-information/4E459E64E1EE7121CA2321435FAECC8A

Prerequisites / notice
This course is aimed at non-physicists, and in particular at students with a background in computer science, mathematics or engineering. Basic linear algebra and calculus knowledge is required (equivalent to first-year courses). Physics knowledge is not required. Physicists and students from a different background than outlined above are welcome at their own risk. Note that while we follow an information-theoretical approach, this is not a course on quantum information theory or quantum computing. It therefore complements those courses offered at ETH Zurich.

This course can be taken in parallel to Quantum Information Processing I & II.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed
402-0442-00L  Quantum Optics  W  10 credits  3V+2U  A. Imamoglu

Abstract
This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

Objective
The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.

Content
This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics that are covered include:

- coherence properties of light
- quantum nature of light: statistics and non-classical states of light
- light matter interaction: density matrix formalism and Bloch equations
- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

Lecture notes
Selected book chapters will be distributed.

Literature
- Text-books:
  - G. Grynberg, A. Aspect and C. Fabre, Introduction to Quantum Optics
  - R. Loudon, The Quantum Theory of Light
  - Atomic Physics, Christopher J. Foot
  - Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
  - C. Cohen-Tannoudji et al., Atom-Photon-Interactions
  - M. Scully and M.S. Zubairy, Quantum Optics
  - Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

402-0448-01L  Quantum Information Processing I: Concepts  W  5 credits  2V+1U  J. Renes

Abstract
This theory part QIP I together with the experimental part 402-0448-02L QIP II (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master’s degree programme in Physics.

Objective
The course covers the key concepts and formalism of quantum information processing. Topics include quantum algorithms, quantum error correction, quantum cryptography, and quantum metrology, with an emphasis on the power of quantum information processing beyond that of classical information processing. The formalism of quantum states, measurements, and channels is developed in detail.

Content
This course gives an introduction to the fundamental concepts of Quantum Information Processing and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include:

- quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

Lecture notes
Will be provided.

Literature
- Quantum Computation and Quantum Information
  - Michael Nielsen and Isaac Chuang
  - Cambridge University Press

Prerequisites / notice
A good understanding of finite dimensional linear algebra is recommended.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Decision-making: fostered
- Problem-solving: fostered

Personal Competencies
- Critical Thinking: fostered

402-0448-02L  Quantum Information Processing II: Implementations  W  5 credits  2V+1U  A. Wallraff, J.-C. Besse

Abstract
This experimental part QIP II together with the theory part 402-0448-01L QIP I (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master’s degree programme in Physics.

Objective
The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum circuits, quantum algorithms (Shor, Grover, Deutsch-Josza,...), stabilizer-based quantum error correction, fault-tolerant designs, the BB84 quantum key distribution protocol, and simple methods of quantum metrology.

Content
The topics covered includes the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

Prerequisites / notice
A good understanding of finite dimensional linear algebra is recommended.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Decision-making: fostered
- Problem-solving: fostered

Personal Competencies
- Critical Thinking: fostered

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2115 of 2667
402-0448-01L QIP I (both offered in the autumn semester)
combine to the core course in experimental physics
"Quantum Information Processing" (totally 10 ECTS credits).
This applies to the Master's degree programme in Physics.

Abstract

Objective
Throughout the past 20 years the realm of quantum physics has entered the domain of information technology in more and more prominent ways. Enormous progress in the physical sciences and in engineering and technology has allowed us to build novel types of information processors based on the concepts of quantum physics. In these processors information is stored in the quantum state of physical systems forming quantum bits (qubits). The interaction between qubits is controlled and the resulting states are read out on the level of single quanta in order to process information. Realizing such challenging tasks is believed to allow constructing an information processor much more powerful than a classical computer. This task is taken on by academic labs, startups and major industry. The aim of this class is to give a thorough introduction to physical implementations pursued in current research for realizing quantum information processors. The field of quantum information science is one of the fastest growing and most active domains of research in modern physics.

Content
- Quantum bits
- Coherent Control
- Measurement
- Decoherence
- QIP with
- Ions
- Superconducting Circuits
- Photons
- NMR
- Rydberg atoms
- NV-centers
- Quantum dots

Lecture notes
Course material be made available at www.qudev.ethz.ch and on the Moodle platform for the course. More details to follow.

Literature
Quantum Computation and Quantum Information
Michael Nielsen and Isaac Chuang
Cambridge University Press

Prerequisites / notice
The class will be taught in English language.
Basic knowledge of concepts of quantum physics and quantum systems, e.g from courses such as Physiscs III, Quantum Mechanics I and II or courses on topics such as atomic physics, solid state physics, quantum electronics are considered helpful.

More information on this class can be found on the web site www.qudev.ethz.ch

402-0861-00L Statistical Physics

Objectives
- Knowledge in basic thermodynamics and quantum mechanics.
- Statistical physics: microcanonical ensembles, canonical ensembles and grandcanonical ensembles, applications to simple systems.
- Quantum statistical physics: density matrix, ensembles, Fermi gas, Bose gas (Bose-Einstein condensation), photons and phonons.
- Identical quantum particles: many body wave functions, second quantization formalism, equation of motion, correlation functions, selected applications, e.g. Bose-Einstein condensate and coherent state, phonons in elastic media and melting.
- One-dimensional interacting systems.
- Phase transitions: mean field approach to Ising model, Gaussian transformation, Ginzburg-Landau theory (Ginzburg criterion), self-consistent field approach, critical phenomena, Peierls' arguments on long-range order.

Lecture notes
Lecture notes available in English.

Prerequisites / notice
Knowledge in basic thermodynamics and quantum mechanics.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Problem-solving
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking

A more detailed syllabus will be distributed at the beginning of the class.

Electives
This is a selection of courses particularly suitable for the MSc QE. In agreement with the tutor, students may choose other courses from the ETH course catalogue.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0053-00L</td>
<td>High-Frequency Design Techniques</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>C. Bolognesi, T. Popovic</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible: higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Objective
Familiarize students with the essential tools and principles exploited in the high-frequency design. Introduction to circuit simulation. Introduction to amplifier design.

Content
Introduction to wireless, radio spectrum. Review of vectors and complex numbers, AC circuit analysis, matching networks, distributed circuit design, transmission lines and transmission line equations, reflection coefficients, the Smith Chart and its software, voltage standing wave ratio (VSWR), skin effect, matrix analysis, scattering parameters, electromagnetic fields and waves, amplifier design.

Hands-on experience with measurement equipment.
Introduction: examples of data conversion architectures; information representation; abstraction, categorization and symbolic


assessed

Solid State Electronics and Optics

Content

1. Discrete-time linear systems and filters:

state-space realizations, z-transform and spectrum,
decimation and interpolation, digital filter design,
stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:

probability, random variables, discrete-time stochastic processes;
detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

Lecture Notes

227-0145-00L

Solid State Electronics and Optics

Abstract

"Solid State Electronics" is an introductory condensed matter physics course covering crystal structure, electron models, classification of
metals, semiconductors, and insulators, band structure engineering, thermal and electronic transport in solids, magnetoresistance, and
optical properties of solids.

Objective

Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.

Prerequisites / notice

Recommended background:
Undergraduate physics, mathematics, semiconductor devices

227-0146-00L

Data Conversion System Design

Abstract

This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over
architecture choice down to circuit implementation.

Objective

Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema
systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall
system in terms of dynamic range and linearity. Students will learn the underlying principles of data conversion and be introduced to the
different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or
algorithmic conversion are explained based on their operation principle accompanied with the appropriate mathematical calculations,
including effects of non-idealities in some cases. After successful completion of the course students should understand the concept of an
ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.

Content

- Introduction: examples of data conversion architectures; information representation; abstraction, categorization and symbolic
representation; basic conversion algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy.

- Dual-slope & successive approximation register (SAR) converters: dual slope principle & converter; SAR ADC operating principle; SAR
implementation with a capacitive array; range extension with segmented array.

- Algorithmic & pipelined A/D converters: algorithmic conversion principle; sample & hold stage; op-amp-based converters; multiplying DAC; flash
ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.

- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of
capacitor mismatch on SAR ADC's performance.

- Flash, folding an interpolating analog-to-digital converters; flash ADC principle, thermometer to binary coding, sparkle correction;
limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding
converters; cascaded folding and interpolation.

- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in
switched-capacitor circuits; aperture time uncertainty and sampling jitter.

- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-order delta-sigma modulation,
circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation,
theoretical foundations, single-loop modulator design.

- Digital-to-analog converters: introduction; current scaling D/A converter, current steering DAC, calibration for improved performance,
delta-sigma D/A-converters.

Lecture notes

Slides are available online under https://lis-students.ee.ethz.ch/lectures/analog-to-digital-converters/

Literature

- M. Gustavsson et. al., CMOS Data Converters for Communications, Springer, 2010

Prerequisites / notice

It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.

Competencies

Subject-specific Competencies

Concepts and Theories assessed

Method-specific Competencies

Techniques and Technologies assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

227-0157-00L

Semiconductor Devices: Physical Bases and Simulation

Objective

Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.

Analytical Competencies

Communication

Creative Thinking

Critical Thinking

Personal Competencies

Communication

Creative Thinking

Critical Thinking

227-0101-00L

Discrete-Time and Statistical Signal Processing

Objective

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time
linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory,
LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Content

1. Discrete-time linear systems and filters:

state-space realizations, z-transform and spectrum,
decimation and interpolation, digital filter design,
stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:

probability, random variables, discrete-time stochastic processes;
detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

A detailed script is provided for each lecture, including the exercises and their solutions.

Literature


assessed

Solid State Electronics and Optics

Data Conversion System Design

W

6 credits

4G

H.-A. Loeliger

Wiener filter, LMS adaptive filter, Viterbi algorithm.

227-0145-00L

Solid State Electronics and Optics

W

6 credits

227-0146-00L

Data Conversion System Design

W

6 credits

2V+2U

T. Burger, G. Cervelli, R. Reutemann

A. Schenk, C. I. Roman

Autumn Semester 2024
The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

**Prerequisites / notice**

Handouts of presented slides. No script but an accompanying textbook is recommended.

**Literature**


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**227-0166-00L Analog Integrated Circuits**

**Abstract**

This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

**Objective**

The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsinc properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

**Content**

Subject-specific Competencies

- Further reading will be recommended in the lecture.

**Lecture notes / literature**

The script (in book style) is sufficient. Further reading will be recommended in the lecture.

**Prerequisites / notice**


---

**227-0225-00L Linear System Theory**

**Abstract**

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

**Objective**

Students should be able to formulate the fundamental results in linear system theory to analyze and control linear dynamical systems.

**Content**

- Proof techniques and practices.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Lecture notes / literature**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

---

**227-0311-00L Qubits, Electrons, Photons**

**Abstract**

In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

**Objective**

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!!) basis which will help them in their advanced studies of the following masters: EIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

**Content**

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

**Prerequisites / notice**

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!).

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Data: 02.07.2024 12:39

Autumn Semester 2024

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This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture “227-0166-00L Analog Integrated Circuits” complements this lecture very well in that respect.

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.
The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement process in the framework of quantum mechanics. Exercises serve to consolidate our understanding and insight.

Prerequisites / notice
1. Electrodynamics
2. Physics 1,2
3. Introduction to quantum mechanics

Abstract
The measurement process is at the heart of both science and engineering. Measurement precision is ultimately limited by the laws of quantum mechanics. This course provides the knowledge necessary to understand current state-of-the-art quantum measurement systems operating at their fundamental limits with a particular focus on optomechanical implementations.

Objective
The goal of this course is to understand the quantum limits of measurement precision together with a formal description of the measurement process in the framework of quantum mechanics.

Content
The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. We discuss the "standard quantum limit" as it arises from the balance of measurement imprecision and backaction, before turning to approaches to overcome it and reach the fundamental "Heisenberg limit". The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics. Exercises serve to consolidate our understanding and insight.

Prerequisites / notice
Requirements: A basic knowledge of solid-state physics and of quantum electronics.

Abstract
Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of semiconductors. Because of its inherent taylorability, this system can be seen as the "ultimate quantum designer's material".

Objective
The goal of this lecture is to explore both the rich physics as well as the application of these system for sources and detectors. In fact, devices based on intersubband transitions are now unlocking large area of the electromagnetic spectrum.

Content
The lecture will treat the following chapters:
- Introduction: intersubband optoelectronics as an example of quantum engineering
- Technological aspects
- Electronic states in semiconductor quantum wells
- Intersubband absorption and scattering processes
- Mid-IR and THz ISB Detectors
- Mid-infrared and THz photonics: waveguides, resonators, metamaterials
- Quantum Cascade lasers:
  - Mid-IR QCLs
  - THZ QCLs (direct and non-linear generation)
- further electronic confinement: interflevel Qdot transitions and magnetic field effects
- Strong light-matter coupling in Mid-IR and THz range

Prerequisites / notice
Mostly the original articles, other useful reading can be found in:
- E. Rosencher and B. Vinter, Optoelectronics , Cambridge Univ. Press
- G. Bastard, Wave mechanics applied to semiconductor heterostructures, Halsted press

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2120 of 2667
Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

- Electromagnetic fields and waves (or equivalent)
- Physics I+II

Introduction to Dynamic Programming and Optimal Control.

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.


- Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Advanced Machine Learning provides algorithmic methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation

- Learning Dynamical Systems

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation

- Learning Dynamical Systems

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

- Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Knowledge obtained in the lecture is deepened through practical and/or programming exercises (C++, Code Expert).
Lecture notes

All material (slides, lecture recordings, examples, exercises, etc.) will be published on the course website.

Literature

* B. Stroustrup, A Tour of C++, 3rd Edition, Addison-Wesley, 2022

Prerequisites / notice

Prerequisite: Computer Science I

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed

Social Competencies

Communication fostered
Cooperation and Teamwork fostered

Personal Competencies

Creative Thinking fostered
Critical Thinking fostered

402-0257-00L Advanced Solid State Physics W 10 credits 3V+2U W. Wegscheider

Abstract

This course is an extension of the introductory course on solid state physics.

The purpose of this course is to learn to navigate the complex collective quantum phases, excitations and phase transitions that are the dominant theme in modern solid state physics. The emphasis is on the main concepts and on specific experimental examples, both classic ones and those from recent research.

Objective

The goal is to study how novel phenomena emerge in the solid state.

Content

Today's challenges and opportunities in Solid State Physics:
Phase transitions and critical phenomena, Fermi surface instabilities, Superconductors, Magnetism of insulators, Semiconductors

Lecture notes

The printed material for this course involves: (1) a self-contained script, distributed electronically at semester start. (2) experimental examples (Power Point slide-style) selected from original publications, distributed at the start of every lecture.

Literature

A list of books will be distributed. Numerous references to useful published scientific papers will be provided.

Prerequisites / notice

This course is for students who like to be engaged in active learning. The "exercise classes" are organized in a non-traditional way: following the idea of "less is more", we will work on only about half a dozen topics, and this gives students a chance to take a look at original literature (provided), and to get the grasp of a topic from a broader perspective.

The "compulsory performance element" of this lecture is a presentation of a paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed

Social Competencies

Communication fostered
Cooperation and Teamwork fostered

Personal Competencies

Creative Thinking fostered
Critical Thinking fostered

402-0317-00L Semiconductor Materials: Fundamentals and Fabrication W 6 credits 2V+1U S. Schön, W. Wegscheider

Abstract

This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objective

Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

Content

1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

Lecture notes

https://moodle-app2.let.ethz.ch/course/view.php?id=23113

Prerequisites / notice

The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.
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<th>402-0402-00L</th>
<th>Ultrafast Laser Physics</th>
<th>W 10 credits 3V+2U</th>
<th>L. P. Gallmann</th>
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**Abstract**
Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.

**Objective**
Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.

**Content**
The lecture covers the following topics:

- a) Linear pulse propagation: mathematical description of pulses and their propagation in linear optical systems, effect of dispersion on ultrashort pulses, concepts of pulse carrier and envelope, time-bandwidth product
- b) Dispersion compensation: technologies for controlling dispersion, pulse shaping, measurement of dispersion
- c) Nonlinear pulse propagation: intensity-dependent refractive index (Kerr effect), self-phase modulation, nonlinear pulse compression, self-focusing, filamentation, nonlinear Schrödinger equation, solitons, non-instantaneous nonlinear effects (Raman/Brillouin), self-steepening, saturable gain and absorption
- d) Second-order nonlinearities with ultrashort pulses; phase-matching with short pulses and real beams, quasi-phase matching, second-harmonic and sum-frequency generation, parametric amplification and generation
- e) Relaxation oscillations: dynamical behavior of rate equations after perturbation
- f) Q-switching: active Q-switching and its theory based on rate equations, active Q-switching technologies, passive Q-switching and theory
- g) Active modelocking: introduction to modelocking, frequency comb versus axial modes, theory for various regimes of laser operation, Haus master equation formalism
- h) Passive modelocking: slow, fast and ideally fast saturable absorbers, semiconductor saturable absorber mirror (SESAM), designs of and materials for SESAMs, modelocking with slow absorber and dynamic gain saturation, modelocking with ideally fast saturable absorber, Kerr-lens modelocking, soliton modelocking, Q-switching instabilities in modelocked lasers, inverse saturable absorption
- i) Pulse duration measurements: rf cables and electronics, fast photodiodes, linear system theory for microwave test systems, intensity and interferometric autocorrelations and their limitations, frequency-resolved optical gating, spectral phase interferometry for direct electric-field reconstruction and more
- j) Noise: microwave spectrum analyzer as laser diagnostics, amplitude noise and timing jitter of ultrafast lasers, lock-in detection
- k) Ultrafast measurements: pump-probe scheme, transient absorption/differential transmission spectroscopy, four-wave mixing, optical gating and more
- l) Frequency combs and carrier-envelope offset phase: measurement and stabilization of carrier-envelope offset phase (CEP), time and frequency domain applications of CEP-stabilized sources
- m) High-harmonic generation and attosecond science: non-perturbative nonlinear optics / strong-field phenomena, high-harmonic generation (HHG), phase-matching in HHG, attosecond pulse generation, attosecond technology; detectors and diagnostics, attosecond metrology (streaking, RABBITT, transient absorption, attoclock), example experiments
- n) Ultrafast THz science: generation and detection, physics in THz domain, weak-field and strong-field applications

**Literature**
https://doi.org/10.1007/978-3-030-82532-4

**Prerequisites / notice**
Prerequisites: Basic knowledge of quantum electronics (e. g., 402-0275-00L Quantenelektronik).

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<tr>
<th>402-0442-05L</th>
<th>Advanced Topics in Quantum Optics</th>
<th>W 4 credits 2G</th>
<th>T. Esslinger</th>
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**Abstract**
The lecture will cover current topics and papers in the wider field of quantum optics in an interactive format. Several papers will be presented by the students in the style of a journal club. Selected papers will be contrasted and their strengths and weaknesses discussed by the students in panel discussions. Recent papers on arXiv.org will be discussed and referee reports referee reports.

**Objective**
The aim of the lecture is to deepen and broaden the knowledge about current research in the field of quantum optics. In addition, it will also be discussed and critically examined how research results are communicated via publications and lectures and which techniques are used in the process.

**Content**
We will select topical fields in quantum optics and quantum science and discuss recently published work.

Topics:
- Atoms or ions-based quantum computing
- Quantum simulation
- Opto-mechanics
- Driven and dissipative quantum systems
- Cavity based atom-light interaction
- Topological photonics

The interactive part of the lecture will include presentations of recent papers, panel discussions of recent papers and the writing of a critical assessment of an arXiv paper in the style of a referee report.
Objectives

- The course aims to provide the knowledge necessary for pursuing advanced research in the field of Quantum Optics in condensed matter systems. Fundamental concepts and techniques of Quantum Optics will be linked to experimental research in systems such as quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

Content


Literature

- Lecture notes will be provided
- C. Cohen-Tannoudji et al., Atom-Photon-Interactions (recommended)
- Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics (recommended)
- A collection of review articles (will be pointed out during the lecture)

Prerequisites / notice

- Masters level quantum optics knowledge
- Lecture notes will be provided
- A collection of review articles (will be pointed out during the lecture)
1. Introduction to nanophotonics
2. Wave physics for nanophotonics
3. Characterization of nanomaterials
4. Semiconductors
5. Nonlinear crystals
6. Photonic integrated circuits
7. Optical quantum devices
8. Plasmonics
9. Metasurfaces
10. Graphene & 2D Materials
11. Nanocomposites

Lecture notes
Slides and book chapter will be available for downloading

Literature
References will be given during the lecture

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help

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402-0469-67L Classical and Quantum Parametric Phenomena W 6 credits 3G A. Eichler, A. Grim

Abstract
There are numerous physical phenomena that rely on time-dependent Hamiltonians (or parametric driving) to amplify, cool, squeeze or couple resonating systems. In this course, we will introduce parametric phenomena in different fields of physics, ranging from classical engineering ideas to devices proposed for quantum computing.

Objective
This course is intended for
- Experimentalists who desire to gain a solid theoretical understanding of nonlinear driven-dissipative systems,
- Theorists looking to enter a topical new field,
- Any scientist interested to learn what lies beyond the harmonic resonator.

In the course, the students will grasp the ubiquitous nature of parametric phenomena and apply it to both classical and quantum systems. The students will understand both the theoretical foundations leading to the parametric drive as well as the experimental aspect related to the realizations of the effect. Each student will analyze an independent system using the tools acquired in the course and will present his/her insights to the class.

Content
This course will provide a general framework for understanding and linking various phenomena, ranging from the child-on-a-swing problem to quantum-limited amplifiers, to optical frequency combs, and to optomechanical sensors used in the LIGO experiment. The course will combine theoretical lectures and the study of important experiments through literature.

The students will receive an extended lecture summary as well as numerous Python scripts, including some that are base on the QuTiP library. These tools will enable them to apply analytical and numerical methods to a wide range of systems beyond the duration of the course.

Lecture notes
A full script will be available in the form of chapters from a dedicated book ("Classical and Quantum Parametric Phenomena").

Prerequisites / notice
The students should be familiar with wave mechanics as well as second quantization. Following the course requires a laptop with Python installed to run Jupyter notebooks, including the QuTiP library.

Competencies
Subject-specific Competencies | assessed | | | |
| Concepts and Theories | assessed | | | |
| Techniques and Technologies | fostered | | | |
| Analytical Competencies | assessed | | | |
| Decision-making | fostered | | | |
| Media and Digital Technologies | assessed | | | |
| Problem-solving | assessed | | | |
| Project Management | fostered | | | |
| Communication | fostered | | | |
| Cooperation and Teamwork | fostered | | | |
| Creative Thinking | fostered | | | |
| Critical Thinking | assessed | | | |
| Integrity and Work Ethics | fostered | | | |
| Self-awareness and Self-reflection | fostered | | | |
| Self-direction and Self-management | assessed | | | |

402-0492-00L Experimental Techniques in Quantum and Electro-Optics W 6 credits 2V+1U

Abstract
We will cover experimental issues in making measurements in modern physics experiments. The primary challenge in any measurement is achieving good signal to noise. We will cover areas such as optical propagation, electronics, noise limits and feedback control. Methods for stabilizing frequencies and intensities of laser systems will also be described.
The lecture "Introduction to Magnetism" aims at letting students familiarize themselves with the basic principles of quantum and statistical mechanics. I aim to give an in-depth understanding of experimental issues for students wishing to work on experimental science. The methods covered in the course provide the necessary background for the study of quantum electronics in solid-state physics. The lecture notes will be made available through Moodle and through the ETH JupyterHub. Learning material will be made available through Moodle and through the ETH JupyterHub. Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of modern quantum information laboratory will be discussed and illustrated through active devices in the lecture.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories assessed
- Techniques and Technologies fostered

**Method-specific Competencies**
- Analytical Competencies assessed
- Media and Digital Technologies fostered
- Problem-solving fostered

**Personal Competencies**
- Critical Thinking assessed
- Self-direction and Self-management fostered

**Objective**

**Prerequisites / notice**

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism. Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

**Content**

**Abstract**

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the semiconductor nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

**Literature**

In addition to the lecture notes, the following supplementary books can be recommended:

**Prerequisites / notice**

The lecture is suitable for all physics students, students of Quantum Engineering, and students of Micro- and Nanosystems and is open to students of other scientific disciplines. Students should have a basic background knowledge in quantum mechanics and solid-state physics.

**Semiconductor Nanostructures**

**Abstract**

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the semiconductor nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

**Objective**

The course will cover a number of different areas of experimental physics, including optical elements and propagation, electronics and electronic noise, optical detection, and control theory.

**Literature**

Examples from a modern quantum information laboratory will be discussed and illustrated through active devices in the lecture.

**Semiconductor Nanostructures**

**Abstract**

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

**Objective**

By the end of this course, students will develop the ability to utilize quantum mechanics concepts to estimate the strength of atomic magnetic moments and understand their reciprocal interactions. They will gain proficiency in interpreting experimental measurements on model systems in terms of material composition and an appropriate, phenomenological spin Hamiltonian. For instance, students will be able to recognize whether the magnetic hysteresis observed in some samples arises from slow dynamics or from a phase transition. Lastly, they will be capable of interpreting the occurrence of abrupt transitions or the emergence of characteristic length scales as resulting from the interplay between competing interactions. Altogether, students will acquire the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

**Content**

The lecture “Introduction to Magnetism” aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine real magnets. Understanding why only a few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what “being magnetic” means is essential to address this question properly. Theoretical concepts will be applied to a few selected nano-sized magnets, which will serve as clean reference systems.

**Topics:**
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetism in solids (mechanisms producing inter-atomic exchange interaction in solids, crystal field)
- Magnetic order at finite temperatures (Ising, XY, and Heisenberg models, low-dimensional magnetism)
- Spin precession and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)

**Lecture notes**

Learning material will be made available through Moodle and through the ETH JupyterHub.

**Prerequisites / notice**

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism. Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.
Abstract
The course treats selected families of quantum algorithms, currently the best candidates to achieve a practical quantum advantage over classical computation in physics, chemistry, optimization, sampling and machine learning. Starting from the basics, quantum algorithms are introduced and their feasibility to solve real-world problems in science and industry is critically discussed.

Objective
The course aims to provide a balanced outlook of this transformative technology, discussing strengths and possible limitations of all discussed algorithms, especially in the context of concrete today and future hardware implementation. After the course, students will have a clear understanding of the state-of-the-art of this field (i.e., the applications and algorithms amenable to quantum speedup, types of hardware, and quantum software). The course content is devised to provide first-hand experience with quantum algorithms and stimulate critical thinking. The course will be instrumental for the student's career development in quantum technology and computational science, in academia or industry.

Content
Course content:
- Quantum gates and circuits basics
- Quantum annealing
- Hamiltonian simulations (Trotter, LCU, circuit decompositions)
- Mapping fermionic, bosonic operators to qubits
- Quantum phase estimation and applications
- Variational quantum algorithms (VQE, QAOA)
- Algorithms for sampling and search (Amplitude amplification, estimation, quantum walks, quantum enhanced Markov chains)
- Selected Quantum Machine learning algorithms
- Prospects for quantum advantage

Lecture notes
Lecture notes covering in detail all the course content will be provided.

Literature
- My lecture notes and references therein which are open-access will be more than enough to follow.
- For an introduction to quantum computing and information it could be useful to read specific chapters of Nielsen and Chuang book.

Prerequisites / notice
The course is designed to be self-contained concerning the basics: i.e. the definition of quantum gates and circuits. Prior knowledge in quantum information science is beneficial but not required. Knowledge of basic statistical mechanics and quantum mechanics is required, specifically: linear algebra, spin operators, many-body wavefunctions, Hamiltonians in second quantisation formalism.
Abstract
The QuanTech Workshops are a project-oriented learning environment in the context of quantum technology. Students work in teams, consisting of engineers and physicists, and jointly tackle a quantum engineering project. During the preceding course "Case Studies: Application of Quantum Technologies", students develop project proposals. Successful proposals will be realized in a QuanTech Workshop.

Objective
Students practice development, planning, and execution of a project in the quantum engineering domain. By working in close collaboration with senior scientists and professors from the two departments D-ITET and D-PHYS, the goal is to provide solutions for pressing challenges in the field of quantum technologies.

Prerequisites / notice
Attendance of "227-1831-10L Case Studies: Applications of Quantum Technology" and successful "QuanTech Workshop" proposal.

► Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1800-00L</td>
<td>Master's Thesis ■</td>
<td>O</td>
<td>30 credits</td>
<td>68D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Admission only if ALL of the following apply:

a) bachelor program successfully completed;
b) acquired (if applicable) all credits from additional requirements for admission to master program;
c) successfully completed the semester project.

Note: the conditions above are not applicable to incoming exchange students.

Registration in mystudies required!
Supervisor must be a professor at D-ITET or D-PHYS, see http://master-qa.ethz.ch/education/master-project.html.

Abstract
The Master Program finishes with a 6-months Master Thesis which is directed by a Professor of the Department or a Professor of another Department who is associated with the D-ITET. Students gain the ability to conduct independent scientific research on a specific research problem.

Objective
see above

Prerequisites / notice
Supervisor must be a professor at D-ITET or associated, see https://www.ee.ethz.ch/studies/main-master/projects-and-master-thesis.html

► Science in Perspective

Only courses offered under "GESS Science in Perspective" count in this category. See "Offered in" tab in course view. For more information, please refer to https://gess.ethz.ch/en/studies/science-in-perspective/SiP-FAQs.html

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ITET

Quantum Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Geospatial Engineering Bachelor

► Basic Courses

★★ First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0241-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>M. Akveld, G.-I. Ionita</td>
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<tr>
<td></td>
<td>Mathematical tools for the engineer</td>
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<td>Mathematics as a tool to solve engineering problems.</td>
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<td></td>
<td>Basic mathematical knowledge for engineers.</td>
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<td></td>
<td>Complex numbers.</td>
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<td></td>
<td>Calculus for functions of one variable with applications.</td>
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<td>Simple Mathematical models in engineering.</td>
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<td>Wird auf der Vorlesungshomepage zu Verfügung gestellt.</td>
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<td></td>
<td>Klaus Dürrschnabel, &quot;Mathematik für Ingenieure - Eine Einführung mit Anwendungs- und Alltagsbeispielen&quot;, Springer; online verfügbar unter:</td>
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<td><a href="http://link.springer.com/book/10.1007/978-3-8348-2559-9/page/1">http://link.springer.com/book/10.1007/978-3-8348-2559-9/page/1</a></td>
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<td></td>
<td>Tilo Arens et al., &quot;Mathematik&quot;, Springer; online verfügbar unter:</td>
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<td><a href="http://link.springer.com/book/10.1007/978-3-642-44919-2/page/1">http://link.springer.com/book/10.1007/978-3-642-44919-2/page/1</a></td>
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<td></td>
<td>Meike Akveld und Rene Sperb, &quot;Analysis I&quot;, vdf;</td>
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<td></td>
<td>Urs Stammbach, &quot;Analysis III&quot; (erhältlich im ETH Store);</td>
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<td><a href="https://people.math.ethz.ch/~stammb/analysisskript.html">https://people.math.ethz.ch/~stammb/analysisskript.html</a></td>
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<tr>
<td>401-0141-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Akka Ginosar, R. Prohaska</td>
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<tr>
<td></td>
<td>Introduction to Linear Algebra</td>
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<td>Basic knowledge of linear algebra as a tool for solving engineering problems.</td>
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<td></td>
<td>Understanding of abstract mathematical formulation of technical and scientific problems. Together with Analysis we develop the basic mathematical knowledge for an engineer.</td>
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<td></td>
<td>Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces.</td>
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<td>The lecturer will provide course notes.</td>
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<td></td>
<td>K. Nipp, D. Stoffer, Lineare Algebra, VdF Hochschulverlag ETH</td>
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<td>G. Strang, Lineare Algebra, Springer</td>
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<td>252-0845-00L</td>
<td>Computer Science I</td>
<td>O</td>
<td>5</td>
<td>2V+2U</td>
<td>M. Lüthi, A. Streich</td>
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<tr>
<td></td>
<td>The course covers the basic concepts of computer programming.</td>
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<td>Basic understanding of programming concepts. Students will be able to write and read simple programs and to modify existing programs.</td>
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<td>In the course &quot;Computer Science I&quot;, the competency of programming is taught, applied and examined. Furthermore modeling is taught and applied.</td>
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<td>variables, types, control structures, functions, scoping, recursion, object-oriented programming. The programming language is Python.</td>
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<td>The slides and lecture notes will be made available for download on the course website.</td>
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<td></td>
<td>Learn to Code by Solving Problems</td>
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<td></td>
<td>A Python Programming Primer</td>
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<td></td>
<td>Daniel Zingaro</td>
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<td>Python Crash Course</td>
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<td></td>
<td>A Hands-On, Project-Based Introduction to Programming</td>
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<td></td>
<td>Eric Matthes</td>
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<td></td>
<td>Python for Data Analysis</td>
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<tr>
<td></td>
<td>Data wrangling with pandas, NumPy &amp; Jupyter, 3rd Edition</td>
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<td></td>
<td>Wes McKinney</td>
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<td></td>
<td>103-0313-00L Spatial Planning and Landscape Development</td>
<td>O</td>
<td>5</td>
<td>4G</td>
<td>G. Debrunner, S. Haufler, D. Jerjen</td>
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<td></td>
<td>The lecture introduces the main-features of Swiss spatial planning. Core subjects are e.g., spatial planning as a federal responsibility, spatial planning instruments (federal, cantonal, municipal), as well as systematic problem solving techniques and methodologies of spatial planning. The lecture is complemented with in-depth topics and comparative international examples.</td>
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<td></td>
<td>The Studierenden kennen die Grundzüge der Schweizer Raumplanung, ihre wichtigen Instrumente auf nationaler, kantonaler, regionaler und kommunaler Ebene und systematische Problemlösungsverfahren. Sie können das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Übungsaufgaben umsetzen.</td>
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<td></td>
<td>Klaus Debrunner and his students</td>
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<tr>
<td></td>
<td>- Grundzüge der Raumplanung und ihre wichtigsten Instrumente kennenlernen</td>
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<td></td>
<td>- Erarbeiten der Fähigkeit, räumliche Probleme zu erkennen und Problemlösungsverfahren auf diese anzuwenden</td>
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<td></td>
<td>- Planung und Landnutzungsmanagement als interaktiven und akteursbezogenen Prozess kennenlernen und anwenden</td>
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<td>- Verstehen der mit Ressourcen und Boden verbundenen Potentiale, Nutzungen und Prozesse</td>
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<td>- Das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Fallbeispielen umsetzen können</td>
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</tbody>
</table>
Die Vorlesung deckt die Grundlagen der (Schweizerischen) Raumplanung und Landschaftsentwicklung ab:

- Was ist Raumplanung (Definitionen und Begriffe)
- Aktuelle Herausforderungen, Entwicklungen und Tendenzen der Raumplanung
- Grundprinzipien: historische Entwicklung und Gesetzgebungen der Schweizer Raumplanung
- Die Raumplanung als staatliche Aufgabe – Raumordnungspolitik auf Bundesebene
- Instrumente der Raumplanung auf nationaler, kantonaler, regionaler und kommunaler Ebene (u.a. Sachpläne und Konzepte, Richtplanung, Nutzungsplanung, Sondernutzungsplanung, Mehrwertausgleich)
- Problemlösungsverfahren in der Raumplanung – systemtechnisches Vorgehen
- Thematische Vertiefungen: Siedlungsentwicklung nach innen; Klimaangepasste Raumplanung; Grundeigentum und kooperative Planung; Raumbeobachtung


Lecture notes
Skript und einzelne Dokumente werden ausgegeben. Unterlagen zur Vorlesung werden auf der SPUR-Kursseite und/oder auf Moodle direkt zur Verfügung gestellt.

Literature
• Schneider, A.; Gilgen, A. 2021. Kommunale Raumplanung in der Schweiz, vdf Hochschulverlag AG, ETH Zürich.
• Schneider, A.; Gilgen, A. 2021. Kommunale Raumplanung in der Schweiz, vdf Hochschulverlag AG, ETH Zürich.
• Schneider, A.; Gilgen, A. 2021. Kommunale Raumplanung in der Schweiz, vdf Hochschulverlag AG, ETH Zürich.

103-0214-00L Cartography Fundamentals O 5 credits 4G L. Hurni

Abstract
Basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.

Objective
Acquire basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well designed legends for basic maps.

Content
Definitions "map" and "cartography", map types, current tasks and situation of cartography, map history, spatial reference systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, prepress technology, printing technology, topographic maps, map critics.

Lecture notes
Will be distributed module by module.

Literature

Prerequisites / notice
Further information at http://www.karto.ethz.ch/studium/lehrangebot.html

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2130 of 2667
Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Customer Orientation
- Sensitivity to Diversity

Personal Competencies
- Creative Thinking

103-0116-00L Ecology and Soil Science

Abstract
The lecture deals with ecological and pedological basics, especially from an engineering and spatial planning perspective. Students learn about soil properties, genesis, ecosystem functions and cycles. Soil changes due to natural and human intervention, the resulting soil degradation and functional restrictions as well as soil protection and management are taught.

Objective
- Students know the basic concepts of soil science and ecology.
- Students can explain soil properties, soil ecosystems and material cycles.
- Students can understand, calculate, analyze and assess the effects of human activities on soils and their functions.
- Students can understand and apply engineering and spatial planning approaches to soil protection and management.

Content
Basics of soil science & ecology: Basic terms, definition of soil, soil functions, soil formation, soil composition, soil types and key parameters, connection between soil and ecology,

Soil use & hazards: Soil compaction, erosion, material pollution of the soil, water balance changes & disturbances

Soil protection & management: soil recultivation and soil monitoring, soil in the city, soil and spatial planning, soil monitoring and the role of the federal government

Lecture notes
Lecture notes and slides (in German) can be found on the Moodle page of the course.

Literature


Additional Basic Courses
No offer in Autumn Semester.

Compulsory Courses

Examination Block 1

Number  Title  Type  ECTS  Hours  Lecturers
401-0243-00L Analysis III  O  3 credits  2V+1U  M. Akka Ginosar

Abstract
We will model and solve scientific problems with partial differential equations. Differential equations which are important in applications will be classified and solved. Elliptic, parabolic and hyperbolic differential equations will be treated. The following mathematical tools will be introduced: Laplace and Fourier transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Learning to model scientific problems using partial differential equations and developing a good command of the mathematical methods that can be applied to them. Knowing the formulation of important problems in science and engineering with a view toward civil engineering (when possible). Understanding the properties of the different types of partial differential equations arising in science and in engineering.

Content
Classification of partial differential equations

Study of the Heat equation general diffusion/parabolic problems using the following tools through Separation of variables as an introduction to Fourier Series.

Systematic treatment of the complex and real Fourier Series

Study of the wave equation and general hyperbolic problems using Fourier Series, D'Alembert solution and the method of characteristics.

Laplace transform and it's uses to differential equations

Study of the Laplace equation and general elliptic problems using similar tools and generalizations of Fourier series.

Application of Laplace transform for beam theory will be discussed.

Time permitting, we will introduce the Fourier transform.

Lecture notes
Lecture notes will be provided
large part of the material follow certain chapters of the following first two books quite closely.


The course material is taken from the following sources:

Stanley J. Farlow - Partial Differential Equations for Scientists and Engineers


Prerequisites / notice

Analysis I and II, insbesondere, gewöhnliche Differentialgleichungen.

<table>
<thead>
<tr>
<th>103-0233-10L</th>
<th>Fundamentals of GIS</th>
<th>O</th>
<th>6 credits</th>
<th>5G</th>
<th>M. Raubal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Fundamentals of geographic information systems: spatial data modeling; metrics &amp; topology; vector, raster and network data; thematic data; spatial statistics; system architectures; data quality; spatial queries and analysis; geovisualisation; spatial databases; labs with GIS software.</td>
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<tr>
<td>Objective</td>
<td>Knowing theoretical aspects of geographic information regarding data acquisition, representation, analysis and visualisation. Knowing the fundamentals of geoinformation technologies for the realization, application and operation of geographic information systems in engineering projects.</td>
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</tbody>
</table>
| Content      | - Einführung GIS & GIScience  
- Konzeptionelles Modell & Datenschema  
- Vektorgeometrie & Topologie  
- Rastergeometrie und -algebra  
- Netzwerke  
- Thematische Daten  
- Räumliche Statistik  
- Systemarchitekturen & Interoperabilität  
- Datenqualität, Unsicherheiten & Metadaten  
- Räumliche Abfragen und Analysen  
- Präsentation raumbezogener Daten  
- Geodatenbanken |
| Lecture notes| Vorlesungspräsentationen werden digital zur Verfügung gestellt. |
| Competencies | Subject-specific Competencies: Concepts and Theories assessed  
Techniques and Technologies assessed  
Analytical Competencies assessed  
Decision-making assessed  
Media and Digital Technologies assessed  
Problem-solving assessed  
Self-presentation and Social Influence fostered  
Creative Thinking fostered  
Critical Thinking fostered  
Integrity and Work Ethics fostered  
Self-awareness and Self-reflection fostered  
Self-direction and Self-management fostered |
| Social Competencies | Self-presentation and Social Influence fostered |
| Personal Competencies | Creative Thinking fostered  
Critical Thinking fostered  
Integrity and Work Ethics fostered  
Self-awareness and Self-reflection fostered  
Self-direction and Self-management fostered |

<table>
<thead>
<tr>
<th>103-0187-02L</th>
<th>Satellite Geodesy</th>
<th>O</th>
<th>4 credits</th>
<th>3G</th>
<th>M. Aichinger-Rosenberger</th>
</tr>
</thead>
</table>
| Objective    | - Sicherheit im Umgang mit Koordinaten-, Referenz- und Zeitsystemen  
- Grundlegendes Verständnis der Berechnung von Satellitenbahnen  
- Grundlegendes Verständnis der geodätischen Weltraumverfahren und deren Stärken und Schwächen  
- Kenntnis der wichtigsten Prozesse, die für Änderungen in der Geometrie, der Rotation und dem Schwerefeld der Erde verantwortlich sind. |
| Content      | - Koordinatensysteme, Transformationen  
- Referenz- und Zeitsysteme  
- Grundlagen Satellitenbahnen  
- Weltraumverfahren: VLBI, SLR, DORIS, Altimetrie  
- Schwerefeldmissionen  
- Kombination der Weltraumverfahren zur Bestimmung der Geometrie, Orientierung sowie des Schwerefeldes der Erde  
- Interdisziplinäre Anwendungen (Meteorologie, Klimatologie, Hydrologie, etc..) |
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:

1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

Die Lehrveranstaltung gibt einen Einblick in die heutige Erdbeobachtung mit dem folgenden skizzierten Inhalt:

1. Einführung in die Fernerkundung von Luft- und Weltraum gestützten Systemen
2. Einführung in das Elektromagnetische Spektrum
3. Einführung in optische Systeme (optisch und hyperspektral)
4. Einführung in Mikrowellen-Technik (aktiv und passiv)
5. Einführung in atmosphärische Systeme (meteo und chemisch)
6. Einführung in die Techniken und Methoden zur Bestimmung von Umweltparametern
7. Einführung in die Anwendungen zur Bestimmung von Umweltparametern in der Hydrologie, Glaziologie, Forst und Landwirtschaft, Geologie und Topographie

Lecture notes
Folien zu jeden Vorlesungsblock werden zur Verfügung gestellt.

Literature
Ausgewählte Literatur wird am Anfang der Vorlesung vorgestellt.

**Instructor:** I. Hajnsek

**Teaching Assistant:** P. Bernhard

**Subject-specific Competencies**

- Concepts and Theories assessed
- Techniques and Technologies assessed

**Method-specific Competencies**

- Analytical Competencies assessed
- Decision-making fostered
- Problem-solving assessed

**Social Competencies**

- Communication fostered
- Cooperation and Teamwork fostered

**Personal Competencies**

- Creative Thinking fostered
- Critical Thinking assessed
- Self-awareness and Self-reflection fostered

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**Course Code:** 351-1158-00L

**Objectives**

After successful completion of the course you will be able to:

- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

**Content**

Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

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**Instructor:** U. Renold

**Teaching Assistant(s):** T. Bolli, P. McDonald, O. Streiff Gnöpff

**Competencies**

- Economics assessed
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Creative Thinking fostered
- Critical Thinking assessed
- Self-direction and Self-management assessed

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**Prerequisites / notice**

Not for students belonging to D-MTEC!

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**Literature**


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**Course Code:** 851-0703-00L

**Objective**

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law. They are able to apply the fundamentals in more advanced law classes and to recognize the relevance of law in their own field.
This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:

- Introduction to system modelling and operations research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

Quantitative models and methods of operations research and operations management offer decision support for complex problems. Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analysed and optimized using suitable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:

- Introduction to system modelling and operations research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

A printed script will be made available.

Any standard textbook in Operations Research is a useful complement to the course.

Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.

The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction to specialized project management software as well as agile project management concepts.
Projects are not only the base of work in modern enterprises, but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company-wide success. The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project.

Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

No. The lecture slides and other additional material will be available for download from Moodle a week before each class.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Leadership and Responsibility</td>
<td>Creative Thinking</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
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<td>Problem-solving</td>
<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Integrity and Work Ethics</td>
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<td>Project Management</td>
<td>Negotiation</td>
<td>Self-awareness and Self-reflection</td>
<td>Self-direction and Self-management</td>
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**System Engineering**

Objective

Systems Engineering is a way of thinking that helps engineer sustainable systems, i.e., ones that meet the needs of stakeholders in the short, medium and long term. This course provides an overview of the main principles of Systems Engineering, and includes an introduction to the use of operations research methods in the determination of optimal systems.

The world’s growing population, changing demographics, and changing climate pose formidable challenges to humanity’s ability to live sustainably. Ensuring that humanity can live sustainably requires accommodating Earth’s growing and changing population through the provision and operation of a sustainable and resilient built environment. This requires ensuring excellent decision-making as to how the built environment is constructed and modified.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e., ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions in complex systems.

More specifically upon completion of the course, you will have gained insight into:

- systems engineering as a way of thinking that helps engineer sustainable systems, i.e., ones that meet the needs of stakeholders in the short, medium and long term. A high-level overview of the main principles of System Engineering. The expectations of your efforts throughout the semester.
- situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
- how to set goals and define constraints in the engineering of complex systems.
- how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking.
- how to compare multiple possible solutions over time with differences in the temporal distribution of costs and benefits and uncertainty as to what might happen in the future.
- how to assess values of benefits to stakeholders that are not in monetary units.
- how to assess whether it is worth obtaining more information in determining optimal solution.
- how to take a step back from the numbers and qualitatively evaluate the possible solutions in light of the bigger picture.
- the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.

Content

The lectures are structured as follows:

1. Introduction – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e., ones that meet the needs of stakeholders in the short, medium and long term. A high-level overview of the main principles of System Engineering. The expectations of your efforts throughout the semester.
2. Situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
3. Goals and constraints – How to set goals and constraints to identify the best solutions as clearly as possible.
4. Generation of possible solutions – How to generate possible solutions to problems, considering multiple stakeholders.
5. The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, weighting, and expected value.
6. The idea behind the supply and demand curves and revealed preference methods.
7. The concept of equivalence, including the time value of money, interest, life times and terminal values.
8. The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Internal rates of return.
9. How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.
10. Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. Linear programming and the simplex method.
11. How sensitivity analysis is conducted using linear programming.
12. How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.
13. How to set up and solve problems when there are multiple objectives.

Lecture notes

- The lecture materials consist of a script, the slides, example calculations in Excel, Moodle quizzes, and exercises.
- The lecture materials will be distributed via Moodle before each lecture.
Appropriate literature in addition to the lecture materials will be handed out when required via Moodle.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

#### Elective Blocks

##### Geodesy and Satellite Navigation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturer</th>
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<tr>
<td>103-0139-00L</td>
<td>Geodetic Data Analysis</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Schartner</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The lecture provides knowledge about the analysis of geodetic time series and their modeling as stochastic processes. Besides, Fourier analysis is also discussed in detail, and basic concepts for parameter estimation, significance, and quality control are laid out. Finally, Monte Carlo simulations are discussed as well.</td>
<td></td>
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<tr>
<td><strong>Objective</strong></td>
<td>After completing the course, participants should have the necessary knowledge to analyze geodetic time series and decompose them into their components. They will also be able to perform hypothesis tests and apply Monte Carlo simulations.</td>
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</tbody>
</table>
| **Content** | - Time series analysis (component decomposition, stochastic processes, parametric and non-parametric methods, regression models, significance tests)  
  - Fourier analysis (discrete/continuous, sampling frequency, frequency resolution, aliasing, leakage effects, window functions)  
  - Recapitulation of basics from statistics and probability calculations (density and distribution functions, random variables, correlation, hypothesis tests)  
  - Monte Carlo simulations |
| **Literature** | Literaturquellen werden während des Kurses bekannt gegeben. |
| **Prerequisites / notice** | Linear algebra, basics in statistics and probability theory, parameter estimation |

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturer</th>
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<tbody>
<tr>
<td>103-0135-01L</td>
<td>Global Satellite Navigation Systems</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>M. Aichinger-Rosenberger</td>
</tr>
</tbody>
</table>
| **Objective** | • Erlernen der theoretischen und praktischen Grundlagen der verschiedenen GNSS  
  • Verstehen der wichtigsten Fehlerquellen und der unterschiedlichen Beobachtungsverfahren  
  • Erkennen von Anwendungsmöglichkeiten von GNSS in der Vermessung, Positionierung, Navigation, GIS, im Geomonitoring und in den Erd- und Umweltwissenschaften  
  • Überblick über die verschiedenen GNSS (GPS, GLONASS, Galileo, Beidou, QZSS und INRSS)  
  • Systemkomponenten, Signalstrukturen, Referenz- und Zeitsystemen und Beobachtungsgleichungen für Pseudorange- und Phasenmessungen der GNSS  
  • Bildung von Differenzen und Linearkombinationen der ursprünglichen Beobachtungen  
  • Fehlerquellen: Satellitenbahnen und -uhren, troposphärische und ionosphärische Refraktion, Antennenphasenzentren, relativistische Einflüsse, Mehrwegeffekte und Messrauschen  
  • Einblick in die Bedeutung der speziellen und allgemeinen Relativitätstheorie für die GNSS  
  • Auswertestrategien und Beobachtungsverfahren sowie Methoden zur Lösung der Phasenmehrddeutigkeiten  
  • Referenzstationsnetze und Dienste  
  • Viele Anwendungsbeispiele  
  • Praktische und rechnerische Übungen für die Erfassung und Auswertung der GNSS-Messungen |
| **Content** | **Literature** | Linkebox möglich |

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2136 of 2667
### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered

#### Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: assessed

### Digitisation and 3D Modelling

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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</table>

#### Abstract
Advanced topics in geodetic metrology with focus on approaches to 3d modelling of local real world environments with higher accuracy.

#### Objective
By the end of this course, the students are able to create digital 3d models of the real world covering areas with an extension up to several 100 m with accuracies in the mm- to cm-level range. They can select the appropriate geodetic instruments or terrestrial laser scanners, plan and carry out the required working steps, test the equipment before use, and describe the quality of the results. They know a broad spectrum of visualization options and can assess their respective suitability for various application cases.

#### Content
- Overview: 3D Modelling from planning of data acquisition to visualization of the results
- Modern geodetic instruments
- Atmospheric effects
- Measurement techniques for high accuracy
- Introduction to terrestrial laser scanning
- Test and calibration of measurement instruments
- Point cloud processing: preprocessing, registration & georeferencing
- 3d modelling and visualization of objects, VR/AR/MR

#### Lecture notes
The slides and documents for enhanced study and further reading will be provided online.

#### Literature

### GIS and Cartography

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0717-00L</td>
<td>Geoinformation Technologies and Analysis</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>M. Raubal</td>
</tr>
</tbody>
</table>

#### Abstract
Geoinformationstechnologien und -analysen für Fortgeschrittene: Mobile GIS; Web-GIS & Geo-Web-Services; Spatial Big Data; Zeitliche Aspekte in GIS; Analyse von Bewegungsdaten; Benutzerschnittstellen

#### Objective

#### Content
- Mobile GIS
- Web-GIS & Geo-Web-Services
- Spatial Big Data
- Zeitliche Aspekte in GIS
- Analyse von Bewegungsdaten
- Benutzerschnittstellen

#### Lecture notes
Vorlesungspräsentationen werden digital zur Verfügung gestellt.

#### Literature

### Prerequisites / notice
The course is carried out in German. Basic knowledge of geodetic metrology is required as a prerequisite, corresponding to the learning objectives and content of the course Geodätische Messtechnik GZ. Besides lectures and data processing, the course also comprises extensive practical exercises in the field.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed

#### Social Competencies
- Cooperation and Teamwork: fostered

#### Personal Competencies
- Critical Thinking: assessed
Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Spatial and Environmental Planning

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>103-0325-02L</td>
<td>Integrated Spatial Planning in Cities and Districts</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>G. Di Carlo Alvarez, F. Günther, R. Streit</td>
</tr>
</tbody>
</table>

Abstract
Methodische und instrumentelle Grundlagen der Raumentwicklung werden aus integrierter Sicht (Städtebau, Freiraum, Verkehr) vermittelt und von den Studierenden konkret in einem Zürcher Stadtquartier als Semesterübung angewendet.

Objective
Die Studierenden lernen:
- Ein Repertoire an hilfreichen Werkzeugen sowie Denkmuster aus der Raumplanung kennen
- Quartiere eigenständig zu erkunden, Potentiale sowie Risiken der Raumentwicklung zu erkennen und zu dokumentieren
- Eigene Räumliche Entwicklungskonzepte zu entwerfen und zu präsentieren
- Massnahmen für Schlüsselgebiete zu konkreteren, u.a. hinsichtlich Zeitplanung, Organisation und Kosten

Content
Die Vorlesung vermittelt methodische und instrumentelle Grundlagen zu planerischen Denkmustern und Repertoire sowie Hilfestellungen für Entwerfen, Argumentieren und Entscheiden.

Traffic Systems

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<tr>
<td>101-0415-01L</td>
<td>Public Transport and Railways</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>F. Corman</td>
</tr>
</tbody>
</table>

Abstract
Fundamentals of public and collective transport, in its different forms.
Categorization of performance dimensions of public transport systems, and their implications to their design and operations.

Objective
Teaches the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.
Teaches students to recognize the interactions between the infrastructure design and the production processes, and various performance criteria based on various perspectives and stakeholders.
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate different choices of technologies to suitable cases; optimize the use of resources in public transport.
Fundamentals: Infrastructures and vehicle technologies of public transport systems; interaction between track and vehicles; passengers and goods as infrastructure users; management and financing of networks.

Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings.

Vehicles: Classification, design and suitability for different goals

Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.

Operations: Passenger/Supply requirements for line operations; timetabling, measures of realized operations, capacity

Lecture notes

Slides, in English, are made available some days before each lecture.

Literature

Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies

Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Network Infrastructure

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<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0532-00L</td>
<td>Introduction to Power Grid Infrastructure</td>
<td>W</td>
<td>2</td>
<td>3G</td>
<td>T. Schultz, P. Bühlmann, S. Hedtke</td>
</tr>
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</table>

Abstract

In this lecture, the basics for the construction and operation of power grids are explained. The focus is on the components of the grid, from generation to transport and consumption.

Objectives

- An overview of how the power grid is constructed and which components it requires.
- An understanding of the advantages and disadvantages of the different technologies and systems (e.g. cable and overhead lines or AC and DC voltage).
- An overview of the challenges and opportunities presented by external influences and new technologies.

Content

Electricity is one of the most important forms of energy used by modern society. The availability of electricity has an immense impact on our daily lives and is an essential prerequisite for economic and social development. Electricity is used in almost all aspects of daily life due to its high flexibility of use. From lighting and cooling homes and offices, to running factories and machinery, and powering electric vehicles, electricity is a major driver of modern society.

The goal of this course is to provide an understanding of electricity as a form of energy, its generation, transmission and use. To this end, the necessary systems and components as well as their interaction in one of the largest technical systems in the world, the interconnected power grid, will be presented.

This includes in particular:
- Electricity as a form of energy
- Electricity generation and storage
- Loads
- Transmission components (overhead lines, cables, substations)
- Protection technology
- Grid operation
- HVDC and power electronics for the power grids of the future
- Energy transition and current challenges

Prerequisites / notice

Enrolment only for students in Geospatial Engineering.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management fostered

Personal Competencies

Creative Thinking assessed
Critical Thinking assessed

Electives

Electives ETH Zurich

Course Catalogue of ETH Zurich
### Recommended Electives of Bachelor Degree Programme

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0241-00L</td>
<td>Cartography Lab</td>
<td>W</td>
<td>6</td>
<td>13S</td>
<td>L. Hurni</td>
</tr>
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</table>

**Abstract**
Independent semester work in cartography

**Objective**
Independent semester work in cartography

**Content**
Choice of theme upon individual agreement

**Prerequisites / notice**
Cartography Fundamentals

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
- **Social Competencies**
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Sensitivity to Diversity
- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

**Science in Perspective**

#### Science in Perspective

**Recommended Science in Perspective (Type B) for D-BAUG**

**Language Courses**

**Bachelor's Thesis**

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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<td>10</td>
<td>21D</td>
<td>Supervisors</td>
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</table>

**Abstract**
The Bachelor Programme concludes with the Bachelor Thesis. This project is supervised by a professor. Writing up the Bachelor Thesis encourages students to show independence and to produce structured work.

**Objective**
Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.

**Content**
The contents base upon the fundamentals of the Bachelor Programme. Students can choose from different subjects and tasks. The thesis consists of both a written report and an oral presentation.

**Geospatial Engineering Bachelor - Key for Type**

<table>
<thead>
<tr>
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<th>W</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
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<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
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**Key for Hours**

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<td>exercise</td>
<td>seminar</td>
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<tr>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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**ECTS**
European Credit Transfer and Accumulation System

*Special students and auditors need special permission from the lecturers.*
Spatial Development and Infrastructure Systems Master

Master Studies (Programme Regulations 2021)

Compulsory Courses

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<tr>
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<td>101-0467-01L</td>
<td>Transport Systems</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>E. Heinen, L. Ambühl, B. Martin Iradi</td>
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</table>

Abstract
History, impact and principles of the design and operation of transport systems

Objective
Introduction of the basic principles of the design and operation of transport systems (road, rail, air) and of the essential pathways of their impacts (investment, generalised costs, accessibility, external effects), referring to relatively constant, and factors with substantial future uncertainty, in the past and expected evolution of transport systems.

Content
Transport systems and land use; network design; fundamental model of mobility behaviour; costs and benefits of mobility; transport history

Classification of public transport systems; Characteristics of rail systems, bus systems, cable cars and funiculars, unconventional systems; introduction to logistics; fundamentals of rail freight transports; freight transport systems; intermodal transportation

Network layout and its impact on road traffic. Traffic control systems for urban and inter-urban areas. Fundamentals of road safety and infrastructure maintenance.

Lecture notes
Lecturer notes and slides as well as hints to further literature will be given during the course.

Prerequisites / notice
Obligatory lecture for students of the first semester of MSc Spatial development and Infrastructure Systems.

Competencies

<table>
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<th>Subject-specific Competencies</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
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<td>assessed</td>
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</table>

Method-specific Competencies

| Analytical Competencies | Decision-making | fostered |
| Problem-solving         |                  | fostered |

Social Competencies

| Communication | fostered |
| Cooperation and Teamwork | fostered |

103-0317-00L Spatial Planning and Development

You as students will...
... assess present and future core challenges of spatial planning and development.
... discuss the role of spatial planning and development in shaping our living environment.
... differentiate the levels, scales and tasks of spatial planning instruments and processes.
... reflect on theoretical concepts and practical examples of decision-making of spatial tasks.
... identify and apply spatially relevant principles and systems for action-oriented planning and decision-making.
... acquire theoretical, methodological, practical know-how to examine, clarify, and solve tasks on spatial development

Objective
The overall aim of the course is to raise students' awareness and curiosity about the aspects that guide and shape our environment. Through lectures, readings, discussions, and exercises, the course seeks to achieve this goal by accumulating crucial notions from both theoretical and practice-based examples, and applying such knowledge into tasks of spatial planning.

Content
Spatial development as a discipline deals with the development, (trans)formation, and arrangement of our urban environment. We simultaneously perceive and contribute to its transformation, making space the result of manifold intended and unintended changes. To mediate between different demands, interests and interventions of multiple actors, a forward-looking, evidence-based, and action-oriented planning is necessary. As guidance for future action, (spatial) planning has to be committed to the sustainable handling as well as just allocation of resources, in particular of the non-replicable resource land.

The course focuses on both theoretical concepts and practice-oriented approaches to gain knowledge and be equipped to address current issues in spatial planning and development. This is mirrored in the course's structure made of both of lectures and exercises.

The lecture series introduces necessary key concepts and covers the following main topics:
- Drivers of spatial development, inward development, core tasks and current challenges for (spatial) planners.
- Interplay of formal and informal planning instruments across scales and actors.
- Differentiation urban typologies, their characteristics and challenges
- Types of spatial analysis and key figures
- Planning approaches and the (political) steering of spatial development.
- Types of processes and participation in spatial development.
- Approaches for planning complex urban situations
- Concepts for sustainable development

The exercises provide a framework for practical application of the learned theoretical concepts of spatial planning to real-life situations.

Lecture notes
A course will be set up on Moodle for the provision of lectures and documents, to upload group deliverables and to ask questions in a discussion Forum. All documents provided are exclusively available for use within this course.
The overall objective is to equip students with the necessary skills and knowledge to effectively conduct academic writing, specifically focused on writing a review article, and to introduce them to the use of Generative AI in enhancing their research and writing process. By the end of the course, students should be able to independently:

- search for and evaluate high-quality sources on their chosen topic and use citation management software.
- organize their writing and construct a scientific text, paragraph, and sentence structure using coherent and complete arguments and clear, concise, and specific language.
- understand citation styles and subject conventions, apply references to the chosen reference system, and properly cite all types of sources.
- determine appropriate types of graphs to represent data and create and evaluate effective graphical representations of data.
- present results systematically and persuasively using a consistent, informative slide deck with engaging and accurate visualizations; speak clearly and confidently using effective words, voice, and body language; know how to practice and deliver the presentation.
- review and provide appropriate feedback on peer work, use AI tools to assist in various stages of the writing process, and critically reflect on originality declarations, plagiarism, etc.
Content

Involved chairs are:

Infrastructure Management (IM), Transportation Systems (TS), Traffic Engineering (SVT), Transport Planning (VPL), Spatial Development and Urban Policy (SPUR), Planning of Landscape and Urban Systems (PLUS) and Spatial Transformation Laboratories (STL).

Christian Sailer, education developer at the D-BAUG, has a special focus on interdisciplinary competencies in teaching at the D-BAUG. He therefore takes the lead of this course in collaboration with REAIS chairs, who periodically alternate among themselves.

Lecture notes

All documents relevant for the course (slides, literature, further links, etc.) are provided centrally via the Moodle platform.

Literature


Axhausen, K.W. (2016) Style Guide for Student Dissertations, IVT, ETH Zürich, Zürich (available as download under learning materials)


ETH (2017) Citation etiquette: How to handle the intellectual property of others, ETH, ETH Zürich, Zürich (last retrieved 29.11.2017)


Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Media and Digital Technologies

Social Competencies

Communication

Cooperation and Teamwork

Personal Competencies

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

101-0509-10L Infrastructure Planning

Abstract

This course explains how ideas for infrastructure emerge from strategic planning (macro scale), are taken up in the planning of systems (meso scale) and progress to approval through project evaluation (micro scale). It also provides infrastructure planners with principles for the appraisal of possible projects with and without the explicit valuing of costs and benefits.

Objective

Infrastructure planners ensure our built environment optimally meets our future needs. This is challenging, as the built environment is a large and complex system, which interacts extensively with the natural environment. Additionally, there is considerable uncertainty with respect to the expectations of the built environment in the future, due to the uncertain environment in which we live, e.g. changing technologies and the changing climate. It is in the face of this complexity and uncertainty that infrastructure planners need to help develop strategic goals, and propose and defend specific potential infrastructure improvements and to a large and diverse set of stakeholders.

This course provide infrastructure planners with an understanding of how ideas for infrastructure emerge from strategic planning (macro scale), are taken up in the planning of systems (meso scale) and progress to approval through project evaluation (micro scale). It also provides infrastructure planners with principles for the appraisal of possible projects with and without the explicit valuing of costs and benefits.

More specifically, upon completion of the course students will understand:

- how ideas for infrastructure are generated at a strategic level, are interpreted in the development of system plans and reach concrete project proposals
- how project ideas emerge from system plans and are iteratively developed and appraised until approval
- the principles of system modelling and system modelling over time in appraising and defending infrastructure proposals
- the advantages and disadvantages of explicitly evaluating the costs and benefits in the appraisal of infrastructure proposals and the advantages and disadvantages of not evaluating the costs and benefits in the appraisal of infrastructure proposals.

Content

The course consists of 5 lectures, 4 help sessions and 4 presentation / evaluation sessions. The two hour weekly lecture period is used as follows:

1-Introduction: Strategic planning to project appraisals – This lecture provides an introduction to the course and an explanation of how the impetus for infrastructure modifications emerge from strategic planning and evolve to the appraisal and approval of specific infrastructure projects. The requirements for successful completion of the course are discussed.

2-Project appraisals: Case for change to approval - This lecture explains how project ideas are generated from system plans and iteratively evolve to become an appraised project.

3-Modelling how a system works and doesn't work - This lecture explains the principles of how to model a system to facilitate the appraisal of the project.

4-Modelling how systems evolve over time - This lecture explains how to model how systems evolve over time using Monte Carlo simulations and both system changes and planner decisions triggered by system changes.

5-Appraising potential projects with/without cost benefit analysis - This lecture explains two way of appraising projects. The first can be used when it is possible to explicitly estimate the costs and benefits of the proposed modifications. The second can be used when it is not possible to explicitly estimate costs and benefits of the proposed modifications.

6-10-Help sessions - We use the lecture periods to answer any questions you might have on your project. Your project is due on Friday of week 9.

11-14-Project presentations - In these lecture periods each group will be asked to present their project and be asked to field questions from the lecturers and fellow students. The presentations will be graded by the lecturers. Fellow students will give their impressions of the presentations and ability of the group to answer the questions.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

- The lecture materials consist of handouts, the slides, and example calculations in Excel.

- The lecture materials will be distributed via Moodle two days before each lecture.

Lecture notes

Appropriate literature will be handed out when required via Moodle.

Literature

This course has no prerequisites.
Introduction to the Programming Language R

**Objectives**

- Understand how to import and export data, and how to work with the most important types of R-objects (e.g., vectors, data frames, matrices and lists).
- Learn how to create meaningful and visually attractive graphics and apply this knowledge to several datasets.
- Learn how to apply several types of important functions (e.g., for- and while-loops, if-else statements, data manipulation).
- Understand descriptive statistics and regression analysis and apply this knowledge to analyse several datasets.
- Understand the possibilities of analysing and plotting spatial data.
- Learn how to write own functions.

**Content**

The course has a strong focus on "learning by doing". During the weekly computer lab sessions, students will be given an introduction to the programming language R. Each lab session will start with a short introductory lecture, after which students work through the script and complete the exercises. During the lab sessions, the lecturers will be available to answer individual questions. The main topics that will be covered in the lab sessions are:

- importing and exporting data
- types of R-objects
- data scraping
- plotting data
- descriptive statistics
- data manipulation
- conditionals and loops
- regression analysis
- plotting and analysing spatial data
- writing own functions

In the 7th and 14th week of the course, students have the time to finish the exercises that should be handed in at the end of those weeks.

**Prerequisites / notice**

No prior knowledge of R or any other programming language is required for this course.
Abstract
System of swiss planning law,
Constitutional and statutory provisions,
Space planning and fundamental rights,
Instruments,
Application, legal protection, enforcement,
Practical training.

Objective
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

Content

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999
Hänni, Peter, Planungs-, Bau- und besonderes Umweltschutzrecht, 7.A., Bern 2021

Competencies

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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>Critical Thinking</td>
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</tbody>
</table>

103-0327-00L History of Spatial Planning W 3 credits 2V M. Koll-Schretzenmayr

Abstract
The course examines the patterns of cleavage, conflict, convergence of interest, and consensus that have influenced spatial planning.

Objective
This course aims to provide students with knowledge of the historical background to understand the current spatial structure and to face the current challenges in spatial planning. Social, cultural, and economic forces will be analyzed for the roles they have played in shaping the landscapes and cityscapes and the answers spatial planning had to spatial development. The course focuses on the history of planning ideas, paradigms and approaches. A link is made to current challenges in spatial planning. Students will critically discuss the challenges of spatial planning is facing today.

Lecture notes
Handouts will be available.

Literature
Daniel Kurz: Die Disziplinierung der Stadt - Moderner Städtebau in Zürich 1900 bis 1940. gta Verlag 2008

103-0569-00L European Aspects of Spatial Development W 3 credits 2G A. Peric Momcilovic

Abstract
Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Objective
Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making

Content
- European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system: EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the notion of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

Lecture notes
The documents for the lecture will be provided at the moodle.
Literature

Recommended literature:
- Governance models:
- Planning models:

EU as a political context:

Territorial cooperation in Europe:

Planning families and cultures:

Planning systems in Europe:

Prerequisites / notice
Only for master students, otherwise a special permission by the lecturer is required.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed
- Negotiation assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Abstract
The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

Objective
- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies

Content
- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

Lecture notes
A script and presentation slides for each exercise will be provided on Moodle.

Literature
Will be named in the lecture.

Prerequisites / notice
Basic GIS skills are strongly recommended.
This course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

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**Objective**

Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation;
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

**Lecture notes**

Powerpoint slides are available on the moodle page. Additional documents are handed out as copies.

**Literature**

Basic literature and references are listed on the webpage.

**Prerequisites / notice**

The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

**Competencies**

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**Objective**

Students learn about historical developments and their topicality and learn “from history”. Design contexts are presented on the basis of examples. Students develop a basis for ways of thinking and action for current landscape architectural challenges.

**Content**

The lectures in the fall semester course “History and Theory of Gardens and Landscape Architecture“ provide an overview of the cultural history of nature, the landscape and the garden from its origins to the present day. An in-depth understanding of change as well as the design strategies and characteristics of the most important epochs and their current relevance will be discussed.

**Lecture notes**

Handouts and a bibliography will be provided

**Literature**

Handouts and a bibliography will be provided

**Prerequisites / notice**

Bachelor students: The knowledge taught in the lecture and the exam-relevant literature provided by the lecturer serve as the basis for exam preparation. The course is designed as an annual program. As the written session exam tests knowledge from both the Landscape Architecture I and II lecture series, it is strongly recommended that you attend the course over two semesters.

The examination topics will be announced shortly before the end of the semester. The lecturer will provide texts on the examination topics as pdf files for download. These serve to deepen understanding of the lecture.

Mobility students or students from other departments: Students who only attend the lecture for one semester complete the lecture with an end-of-semester oral examination.

Here too, the lecturer provides literature relevant to the examination as a download.

Students registered for the exam will receive further information on the exam procedure by email shortly before the end of the semester.

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**Objective**

The course provides the basics and tools for an in-depth understanding of the discipline of landscape architecture and its far-reaching perspectives in planning and design processes and to critically reflect on one’s own projects within a specific context.

Students learn about historical developments and their topicality and learn “from history”. Design contexts are presented on the basis of examples. Students develop a basis for ways of thinking and action for current landscape architectural challenges.

**Content**

The lectures in the fall semester course “History and Theory of Gardens and Landscape Architecture“ provide an overview of the cultural history of nature, the landscape and the garden from its origins to the present day. An in-depth understanding of change as well as the design strategies and characteristics of the most important epochs and their current relevance will be discussed.

**Lecture notes**

Handouts and a bibliography will be provided

**Literature**

Handouts and a bibliography will be provided

**Prerequisites / notice**

Bachelor students: The knowledge taught in the lecture and the exam-relevant literature provided by the lecturer serve as the basis for exam preparation. The course is designed as an annual program. As the written session exam tests knowledge from both the Landscape Architecture I and II lecture series, it is strongly recommended that you attend the course over two semesters.

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Objective
This course has the aim of deepening students' knowledge of the environmental assessment methodologies and their various applications. In particular, students completing the course should have the
- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

Content
- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Allocation (multinput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

Lecture notes
No script. Lecture slides and literature will be made available on Moodle.

Literature
Literature will be made available on Moodle.

Prerequisites / notice
Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Media and Digital Technologies
Problem-solving

Personal Competencies
Critical Thinking

103-0251-00L Computational Methods for Geospatial Analysis W 4 credits 4G K. Schindler, J. A. Butt, O. Dietrich, B. Soja, N. Wiedemann

Abstract
Introduction to mathematical and statistical tools for geospatial data analysis.

Objective
The goal is to familiarise students with the principles and tools of geospatial data analysis, and to enable them to apply those tools to practical tasks.

Content
The course introduces basic methods of geostatistics and geospatial data analysis. Topics include spatial correlation, auto-correlation and the variogram; surface interpolation (kernel-based, kriging, parametric surface models); spatially adaptive filtering (bilinear, guided filter); spatial stochastic processes and random fields; time series models and spatio-temporal analysis.

Prerequisites / notice
Bachelor level mathematics: analysis, linear algebra, statistics and probability theory, parameter estimation. Basic knowledge of multivariate statistics and machine learning is recommended.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making

Personal Competencies
Creative Thinking
Critical Thinking

103-0573-00L Social Science Research for Urban Planning & Urban Studies: Quantitative & Qualitative Methods W 4 credits 2G M. Wicki, D. Kostenwein

Abstract
This course explores research designs and methods as tools in urban planning and urban studies. Students will actively engage with quantitative and qualitative methods. A focus lies on active learning from examples that apply the discussed methods. In the end, students can create coherent research designs by formulating relevant research questions and assessing and discussing suitable methods.

Objective
Overarching learning objective: To create coherent research designs by formulating relevant research questions and assessing and discussing suitable methods.

Specific objectives:
- Know and critically assess urban research methods
- Select, investigate, and learn to apply urban research methods
- Interpret and discuss urban research projects by evaluating the applied research methods
- Create coherent research designs

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making

Social Competencies
Communication
Cooperation and Teamwork
Self-presentation and Social Influence

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking

052-0715-24L Topology n W 2 credits 2K P. Urech, M. Vollmer

Abstract
The elective course “Topology” in the Autumn Semester 2023 builds on a long standing specialization in the spatial exploration of the landscape. We will embark the participants on a terrain that we shape through our own thoughts and actions, adopting different perceptual perspectives, supported by examples from art, literature, technology and history.
**Objective**
This elective course gives architecture students the opportunity to further develop their perception of space through a site-specific approach in the field of landscape architecture. The students will learn to use 3D point cloud technology and other spatial sensing technologies in order to analyze complex urban landscape and develop new ways of editing and representing these intertwined spaces.

**Content**
Students will document and analyze a case-study site to reveal its topological potentials and sensory qualities. This understanding will be gained through point cloud modeling and audiovisual composition. In particular, we will develop a new, comprehensive sectional model of a topographically interesting site situation.

Students will become acquainted to working with point cloud models produced with laser-scanning. Through a series of steps, they will learn how a laser-scanning survey is conducted, how the raw data is processed, how point cloud models are assembled, what qualifies these models can provide to analyze, explore and represent space as an audiovisual experience. Collected samples from the field will be assembled and built into an interactive application in the «Landscape Visualization and Modelling Lab». All software required is open source and can also be installed on private laptops, facilitating work from home if necessary.

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**Prerequisites / notice**
- The course is limited to 20 students (based on available computer stations)
- Students will work in groups of 2
- The lectures will be held in English, assistance in English and German
- The enrolment will be prioritized by the time of inscription and balanced between departments

**Lecture notes**
Literature will be provided during the course.

**063-0701-24L Methods of Urban Research: Extended Urbanisation**

- **Method-specific Competencies**
  - Analytical Competencies: fostered
  - Decision-making: assessed
  - Problem-solving: assessed
  - Project Management: fostered

- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Leadership and Responsibility: fostered
  - Sensitivity to Diversity: assessed

- **Personal Competencies**
  - Adaptability and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: assessed

**Abstract**
While architects, planners, and urban designers have engaged with the city, the analysis of urbanising territories ‘beyond the city’ have been a blind spot. This lecture series attempts to close this gap by discussing with researchers who will present methods, experiences and findings from a great variety of territories of extended urbanisation.

**Objective**
The lecture series “Methods of Urban Research: Extended Urbanisation” presents the methodology of sociological analysis of territories of extended urbanisation. These territories, which have traditionally been beyond the sensorium of architecture and urban design professions provide important terrains for urban practice. The lecture series will bring together researchers that have been part of a long-standing research project on territories of extended urbanisation. They will present a kaleidoscopic overview of the diverse methods and insights into international research on urbanisation processes in large metropolises and in territories characterized by extended urbanisation. Most of the presented case studies are published in the brand new book “Extended Urbanisation: Tracing Planetary Struggles”.

Semester performance will be assessed on the basis of a written group assignment on extended urbanization (approximately 10 pages, in groups of four). For the assignment - describe and analyse an example of extended urbanization in a geography of your choice. The example may be from Switzerland or from any other region of the planet. Based on scientific literature and other data, conduct a critical analysis of the chosen case study, and discuss the consequences of urbanization of this area for its people and the environment. Develop a possible urban strategy for alternative inclusive development. Summarize your findings through a A3-sized poster.

**Content**
Introduction: Christian Schmid
- Contesting the dispossession of Land and Nature. The Peripheralisation of Arcadia - Metaxia Markaki
- The Horizontal Factory. The Operationalisation of the US Corn and Soy Belt - Nikos Kastikis
- Losing Sea. Abstraction and the End of the Commons in the North Sea - Nancy Couling
- The Mine, the City and the Encampment. Contesting Extractivism in Eastern Amazonia - Rodrigo Castriota
- Palm Oil and Extended Urbanisation in the Malaysian Hinterland - Hans Hortig
- Urbanisation en Route. The Lagos-Abidjan Corridor - Alice Herzog
- Extended Urbanisation in Guateng, South Africa - Lindsay Howe
- The Extended Urbanisation of Beijing - Yiqui Liu
- The Highway Revolution. Enclosure and State Space in India - Nitin Bathla
- Concluding Discussion

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Abstract
This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.
Objective

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view.

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning, timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.

Content
Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes
Lecture slides are provided.

Literature
Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

151-0227-00L Basics of Air Transport (Aviation I) W 4 credits 3G P. Wild

Abstract
In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation.

The program is taught in English and we provide 11 different experts/lecturers.

Objective
The goal is to understand and explain basics, principles and contexts of the broader air transport industry. Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport. Ideal foundation for Aviation II - Management of Air Transport.
### Transport Planning Methods

**Content**
Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Planning; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

**Technical visit:**
This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

**Prerequisites / notice**
Special permission from the instructor can be requested if the student has not taken Verkehr III - Road Transport Systems 6th Sem. BSc (101-0415-00L)

**Literature**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Analytical Competencies</td>
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<td>fostered</td>
<td>fostered</td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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</tbody>
</table>

**Competencies**
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making support tool

**Objective**
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis.

Interim lab session take place regularly to guide and support students with the applied part of the course.

**Lecture notes**
Preparation materials & slides are provided prior to each class

**Literature**

Abstract

Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signaling systems
- Standards
- Availability and safety
- Traffic control and maintenance

Objective

- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

Content

EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale

1 Einführung:
1.1 Geschichte und Struktur des Bahnsystems
1.2 Fahrdynamik

2 Vollbahnfahrzeuge:
2.1 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
2.2 Bremsen
2.3 Traktionsantriebssysteme
2.4 Hilfsbetriebe und Komfortanlagen
2.5 Steuerung und Regelung

3 Infrastruktur:
3.1 Fahrweg
3.2 Bahnstromversorgung
3.3 Sicherungsanlagen

4 Betrieb:
4.1 Interoperabilität, Normen und Zulassung
4.2 RAMS, LCC
4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Geplante Exkursionen:
Betriebszentrale SBB, Zürich Flughafen
Reparatur und Unterhalt, SBB Zürich Altstetten
Fahrzeugfertigung, Stadler Bussnang

Lecture notes
Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice
Dozent:
Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Critical Thinking assessed

Urban Systems and Transportation

This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

Objective

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.
Content

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong microfoundations and allow for precise policy recommendations.

Lecture notes
Course slides will be made available to students prior to each class.

Literature
Course slides will be made available to students.

Competencies

- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Communication fostered
- Personal Competencies: Creative Thinking fostered, Critical Thinking fostered

101-0492-00L Microscopic Modelling and Simulation of Traffic Operations

Abstract
The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.

Objective
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.);
- Design a road transport network inside the simulation software;
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network;
- Understand how to design a complete study, implement and validate it for planning purposes, e.g., creating a new road infrastructure;
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content
In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.

Microscopic modelling and simulation concepts will include:
1) Car following models
2) Lane change models
3) Calibration and validation methodology
Specific tasks for the project will include:
1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/Extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.
The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.
Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.);
- Design a road transport network inside the simulation software;
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network;
- Understand how to design a complete study, implement and validate it for planning purposes, e.g., creating a new road infrastructure;
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Lecture notes
The lecture notes and additional handouts will be provided before the lectures.

Literature
Additional literature recommendations will be provided at the lectures.

Prerequisites / notice
Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

Competencies

- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Communication fostered
- Personal Competencies: Creative Thinking assessed, Critical Thinking assessed

101-0491-00L Agent Based Modeling in Transportation

Abstract
This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based simulation models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in groups.
At the end of the course, the students should:
- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform transportation studies

This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained.
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

**Prerequisites / notice**

There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

For those without object-oriented programming experience, a crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

**Competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Techniques and Technologies</th>
<th>Assessed</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
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<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Fostered</td>
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<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>Assessed</td>
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</table>

**Objective**

Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

**Content**

Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

**Further literature will be presented during the course.**

**Lecturers**

M. Deublein, P. Eberling

**Literature**


**101-0491-10L Basics of Java and Best Practices for Scientific Computing**

This course provides an introduction to programming in Java, version control, and cloud computing.

**Objective**

At the end of the course, the students should:
- have acquired object-oriented programming skills with a focus on Java.
- have an understanding of version control using git
- have learned to deploy java applications on servers

**Content**

This course provides an introduction to object-oriented programming with Java. Four topics are covered:
- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods,...)
- Injection (traditional vs. Guice)
- Code versioning
- Java application deployment on servers

**Lecturers**

M. Balac

**Literature**

Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang

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**101-0492-00L Microscopic Modelling and Simulation of Traffic Operations**

The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.

**Lecturers**

M. Makridis

**Literature**

Objective

The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:

- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.

Microscopic modelling and simulation concepts will include:

1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:

1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/extend the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students.

It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Lecture notes

The lecture notes and additional handouts will be provided before the lectures.

Literature

The slides will be made available.

Additional literature recommendations will be provided at the lectures.

Prerequisites / notice

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

Competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Media and Digital Technologies
Problem-solving

Social Competencies

Cooperation and Teamwork

Personal Competencies

Creative Thinking
Critical Thinking

101-0469-00L Road Safety W 6 credits 4G M. Deublein, P. Eberling

Abstract

The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety Aspects are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

Objective

Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety

Content

Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy

Literature


Further literature: will be presented during the course

101-0419-02L Railway Infrastructures 2 W 2 credits 2G U. A. Weidmann, M. Kohler, M. J. Manhart

Abstract

Railway technology; interaction between track and vehicles; stress; track construction including features of railway bridges and tunnels; starting up; track diagnostics and forcast; track maintenance and related methods

Objective

Understanding the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.

Content

1 - Railway technology
Track, power supply / catenaries, information technology, safety / interlockings / dispatching

2 - Interaction
Interaction between track and vehicles, vehicle dynamics

3 - Railway Track
Stress; track construction including special features of railway bridges and tunnels

4 - Starting up
Goals, methods, procedures

5 - Diagnostics, maintenance strategies
Track diagnostics and forcast

6 - Track maintenance
Maintenance strategies, fundamentals of track maintenance and related methods

Lecture notes

The slides will be made available.


Further literature: will be presented during the course
Prerequisites / notice
Prerequisite: 101-0419-01 Railway Infrastructures 1 (FS)

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: fostered

Social Competencies
- Customer Orientation: assessed
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: assessed

Major Courses for all Majors

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0541-00L</td>
<td>Economic Dynamics and Complexity</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>F. Schweitzer, L. Verginer</td>
</tr>
</tbody>
</table>

Abstract
What causes economic business cycles? How are limited resources, competition, and cooperation reflected in growth dynamics? To answer such questions, we combine macroeconomic models and methods of nonlinear dynamics. We study the role of bifurcations and control parameters for dynamic stability. Feedback cycles and coupled dynamics are reasons for limited predictability, instability and chaos.

Objective
- successful participant of the course is able to:
  - understand the importance of different modeling approaches
  - formalize and solve one- and two-dimensional nonlinear models
  - identify critical conditions for stability and dynamic transitions
  - analyze macroeconomic models of business cycles, supply and demand
  - apply formal concepts to model economic growth and competition

Content
System theory sees the economy as a complex adaptive system. What does this mean for economic modeling? We focus on two sources of complexity: (a) nonlinear dynamics, which is captured in this course, “Economic Dynamics and Complexity” and (b) collective interactions, which is captured in the course “Agent-Based Modeling of Economic Systems” (in Spring).

Our approach to economic dynamics combines insights from different disciplines: macroeconomics studying business cycles and growth, system dynamics rooted general system theory and cybernetics, and nonlinear dynamics using applied mathematics.

We start with a comparison of different modeling approaches, to highlight the problems and challenges of system modeling.

Emphasis is on the formal analysis of these models using methods from applied mathematics and tools for solving coupled differential equations.

Weekly self-study tasks are used to apply the concepts introduced in the lectures. We practice how to solve nonlinear models formally and numerically and how to interpret the results.

Lecture notes
- The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

Prerequisites / notice
- Students should be familiar with nonlinear differential equations and should have basic programming skills. All necessary details to solve nonlinear models will be provided in the course. The course will not build on mathematical proofs, optimization, statistics, efficient numerical computation and other specialized skills.

Interdisciplinary Project Work

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
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<td>O</td>
<td>16 credits</td>
<td>34A</td>
<td>A. Grêt-Regamey</td>
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</tbody>
</table>

Abstract
The Interdisciplinary Project Activity (IPA) forms the key feature of the MSc RE&IS. Students work on an interdisciplinary task from the field of spatial development and infrastructure systems in a real-life application. The interdisciplinary cooperation and strong communication skills are crucial skills required in practice to communicate with and between relevant actors and other stakeholders.
Upon completion of the Interdisciplinary Project Activity, students will have gained experience in:

1) Investigating and understanding the project area as well as identifying, evaluating and formulating the current challenges and relevant topics within that area.

2) Creating, designing, developing and evaluating an overall integrated strategy for an urban area with relevant interventions as well as an in-depth study of either a focus area or focus topic within the given urban area.

3) Organising, structuring and fostering teamwork within an interdisciplinary group of 4-5 students in self-responsibility.

4) Applying previously learnt interdisciplinary methodological and theoretical skills from different fields to create solutions to real-world challenges as well as arguing for the solutions' suitability.

5) Evaluating and choosing effective ways of presenting and communicating information (e.g., text, statistics, images, etc.), ideas, and recommendations throughout the whole semester.

6) Understanding, developing, strengthening, and critically self-evaluating their disciplinary position and role in planning urban development.

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### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<td>Supervisors</td>
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</table>

**Objective**

The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the student's ability to work independently and to produce scientifically structured work.

**Title**

Only for Spatial Development and Infrastructure Systems MSc, Programme Regulations 2021.

**Abstract**

Before starting the Master's thesis, students must have

- obtained the Bachelor's degree;
- fulfilled all specified admission conditions, if any;
- acquired at least 90 credits in the Master's programme, including the required credits for compulsory courses and for interdisciplinary project work.

The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

**Content**

To work independently and to produce a scientifically structured work.

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.
Global History of Urban Design I

**Objective**

The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.

**Content**

In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

- 01. The History and Theory of the City as Project
- 02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
- 03. The Idea of the Polis: Rome, Greece and Beyond
- 04. The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
- 05. Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
- 06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization
- 07: The City of Labor: Company Towns as Cross-Cultural Phenomenon
- 08: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
- 09: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
- 10: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

**Lecture notes**

Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

**Literature**

There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

**Prerequisites / notice**

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

**Competencies**

- Subject-specific Competencies: Concepts and Theories, assessed
- Social Competencies: Communication, fostering
- Personal Competencies: Negotiation, fostering

**Additional skills:** Students acquire experience in teamwork.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2159 of 2667
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM, Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
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<td>Self-presentation and Social Influence</td>
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<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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### Literature


MATSIm


Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

### Prerequisites / notice

There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

For those without object-oriented programming experience, a crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with traffic fundamentals, microscopic traffic models, and toolboxes for simulation. The project is a group effort that requires weekly meetings. The students work in pairs on a group project that completes in the end of the semester. The project will consist of weekly 2-hour lectures. The students work in pairs on a group project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration, and validation) and will develop alternative scenarios regarding modifications on the infrastructure, simulation of in-vehicle technologies, and vehicle-to-everything (V2X) communication. Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret, and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze, and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:

1. Understand the basic models used in microscopic simulation software (car-following, lane changing, gap acceptance, give ways, on/off ramps, etc.).
2. Design a road transport network inside the simulation software.
3. Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
4. Understand how to design a complete study, implement and validate it for planning purposes, e.g., creating a new road infrastructure.
5. Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

In this course, the students will first learn some microscopic modeling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modeling and simulation concepts will include:

1. Car following models
2. Lane change models
3. Calibration and validation methodology

Specific tasks for the project will include:

1. Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2. Calibrating and validating the simulation model.
3. Redesigning/ extending the model to improve traffic performance through Aimsun and with/without programming in Python or C++.

Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration, and validation) and will develop alternative scenarios regarding modifications on the infrastructure, simulation of in-vehicle technologies, and vehicle-to-everything (V2X) communication. Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret, and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze, and present a novel proposal, which will be compared with the base scenario.

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2. Calibrating and validating the simulation model.
3. Redesigning/ extending the model to improve traffic performance through Aimsun and with/without programming in Python or C++.

The course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advanced lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.
This course provides an introduction to programming in Java, version control, and cloud computing.

At the end of the course, the students should:
- Have acquired object-oriented programming skills with a focus on Java.
- Have an understanding of version control using git
- Have learned to deploy Java applications on servers

This course provides an introduction to object-oriented programming with Java. Four topics are covered:
- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods, ...)
- Injection (traditional vs. Guice)
- Code versioning
- Java application deployment on servers

Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang

### Major in Network Infrastructure

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>101-0258-00L</td>
<td>River Engineering</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Weitbrecht, I. Schalko, K. Sperger</td>
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</table>

**Abstract**
The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

**Objective**
At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river.
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

**Content**
The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river rehabilitation project at the Alpine Rhine in Austria and Switzerland.

**Lecture notes**
Lecture slides can be downloaded via Moodle.

**Literature**
1. Erosion and Sedimentation; Pierre Y. Julien
2. River Mechanics; Pierre Y. Julien

**Prerequisites / notice**
Recommended lectures:
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

**Competencies**

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<td>Self-direction and Self-management</td>
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### Major in Road Safety

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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>101-0469-00L</td>
<td>Road Safety</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>M. Deublein, P. Eberling</td>
</tr>
</tbody>
</table>

**Abstract**
The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

**Objective**
Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety

**Content**
Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy

**Literature**

Further literature: will be presented during the course
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
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In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:

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Specific tasks for the project will include:
1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/ extending the model to improve the traffic performance through Aimsun and with/ without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

101-0419-02L Railway Infrastructures 2 W 2 credits 2G U. A. Weidmann, M. Kohler, M. J. Manhart

Abstract
Railway technology: interaction between track and vehicles; stress; track construction including features of railway bridges and tunnels; starting up; track diagnostics and forecast; track maintenance and related methods

Objective
The lecture gives a deeper insight into railway technology, the interaction between track and vehicles as well as in construction and dimensioning of the track. Methods for starting up and the diagnosis of the state of the track and its forecast are shown. State-of-the-art maintenance strategies and technologies are presented.

Content
1) Railway technology
   Track, power supply / catenaries, information technology, safety / interlockings / dispatching
2) Interaction
   Interaction between track and vehicles, vehicle dynamics
3) Railway Track
   Stress; track construction including special features of railway bridges and tunnels
4) Starting up
   Goals, methods, procedures
5) Diagnostics, maintenance strategies
   Track diagnostics and forecast
6) Track maintenance
   Maintenance strategies, fundamentals of track maintenance and related methods

Lecture notes
The slides will be made available.
Prerequisites / notice
Prerequisite: 101-0419-01 Railway Infrastructures 1 (FS)

Literature
A list with related technical literature will be handed out.

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Subject-specific Competencies: fostered, assessed
Method-specific Competencies: fostered, assessed
Social Competencies: fostered, assessed
Personal Competencies: fostered, assessed

### 101-0187-00L Structural Reliability and Risk Analysis

**Number** 101-0187-00L  
**Title** Structural Reliability and Risk Analysis  
**Type** W  
**ECTS** 3 credits  
**Hours** 2G  
**Lecturers** S. Marelli

**Abstract**
Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.

**Objective**
The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field. Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro-codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

**Lecture notes**
Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.

**Literature**
- S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.

**Prerequisites / notice**
Basic course on probability theory and statistics

### Electives

The entire course programs of ETH Zurich and University Zurich are open to the students to individual selection. The students have themselves to check whether they meet the admission requirements for a course.

#### Recommended Electives of Master Degree Programme

**Number** 103-0227-00L  
**Title** Application Development in Cartography  
**Type** W  
**ECTS** 6 credits  
**Hours** 4G  
**Lecturers** A. Neumann

**Abstract**
This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

**Objective**
Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.

**Content**
- 3D cartography  
- Web mapping  
- Data processing  
- Animations and interactions  
- Map and UI design  
- Web application development  
- Programming (JavaScript);

**Lecture notes**
Handouts of the lectures and exercise documents are available on Moodle.

**Prerequisites / notice**
Cartography II or Introduction to Web Cartography Part 1+2 (MOOC) or similar knowledge in mapping with JavaScript.

**Competencies**
- Subject-specific Competencies: assessed
- Method-specific Competencies: assessed
- Social Competencies: assessed
- Personal Competencies: assessed

**Method-specific Competencies**
- Techniques and Technologies  
- Analytical Competencies  
- Decision-making  
- Problem-solving  
- Project Management

**Social Competencies**
- Customer Orientation  
- Sensitivity to Diversity

**Personal Competencies**
- Adaptability and Flexibility  
- Creative Thinking  
- Critical Thinking  
- Integrity and Work Ethics

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This class introduces to practice-relevant basics of construction and real estate law.

Introduction (most important sources of construction and real estate law), SIA (Swiss Society of Engineers and Architects) Design Engineering Services Contract, SIA-Norm 118 (SIA General Terms and Conditions for Construction Services), liability of designers/civil engineers, construction insurance, property law for civil engineers, sale of land, contaminated sites, statutory mortgage for contractors, public procurement, litigation in construction and real estate, the civil engineer as expert, What else to know ...

There are ‘Lecture Notes’ (in German) for this course.

This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

This course provides a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Production Planning, Scheduling and Control, Factory Management, Supply Chain Management, and Inventory Management. Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:

2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.

3.0 credits

Principles of Natural Hazard Management

As future construction practitioners, students are able to recognise legal problems independently and in good time in their daily work and to initiate the right measures.

Introduction to mathematical optimization, and their applications to a variety of problems in engineering.

The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Topics covered in this course include:

- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Information about relevant literature will be given in the lecture.

This course is meant for students who did not attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

This course covers the following topics: "Mathematical Optimization", Introduction to Mathematical Optimization, Linear Programming, and Combinatorial Optimization.

This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:

2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.

3.0 credits
This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts and a field trip.

By the end of the course, students will be able to:

- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- identify and discuss the development of natural hazards in the context of climate change.

The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.
Content

Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro-codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FORM) and the first order reliability method (FOSM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

Lecture notes

Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.

Literature


S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.

Prerequisites / notice

Basic course on probability theory and statistics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Winter Term</th>
<th>Credits</th>
<th>ECTS</th>
<th>Lecturer</th>
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<tbody>
<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td></td>
<td>W</td>
<td>3</td>
<td>J.-E. Sturm</td>
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</table>

Abstract

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes

The course Moodle page contains announcements, course information and lecture slides.

Literature


This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Competencies

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Method-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Assessed

363-0503-00L Principles of Microeconomics

W 3 credits 2V J.-E. Sturm

Abstract

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes

The course Moodle page contains announcements, course information and lecture slides.

Literature


This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Competencies

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Method-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Assessed

401-3901-00L Linear & Combinatorial Optimization

W 10 credits 4V+2U R. Zenklusen

Abstract

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.
Content

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature


Prerequisites / notice

Solid background in linear algebra.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

101-0258-00L River Engineering

Abstract
The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

Objective
At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content
The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river rehabilitation project at the Alpine Rhine in Austria and Switzerland.

Lecture notes
Lecture slides can be downloaded via Moodle.

Literature
1. Erosion and Sedimentation; Pierre Y. Julien
2. River Mechanics; Pierre Y. Julien

Prerequisites / notice

Recommended lectures:
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Short practical exercises (voluntary) will be offered throughout the semester to improve the application of the learned subjects.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed

Social Competencies
- Communication: fostered

Personal Competencies
- Cooperation and Teamwork: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

052-0707-00L Urban Design III

Abstract
Students are introduced to a narrative of ‘Urban Stories’ through a series of three tools driven by social, governance, and environmental transformations in today’s urbanization processes. Each lecture explores one city’s spatial and organizational ingenuity born out of a particular place’s realities, allowing students to transfer these inventions into a catalog of conceptual tools.
How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-relevant decisions to the city rather than a single client? How can we design with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series introduces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practitioner insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series introduces urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
- Toolbox ‘Reader’ with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings
- Reading material will be provided throughout the semester.

**Objective**

- How can students of architecture become active agents of change?
- What does it take to go beyond a building's scale, making design-relevant decisions to the city rather than a single client?
- How can we design with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule?
- How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process?

**Content**

- Urban form cannot be reduced to physical space.
- Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents.
- Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems.
- Current urban phenomena are the result of urban evolution.
- The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects.
- This imaginary city exists along with its potentials and problems and with the conflicts that have evolved.
- Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

- How did cities develop into the cities we live in now?
- Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change.
- We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments.
- We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

**Lecture notes**

- The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
  - Toolbox ‘Reader’ with an introduction to the lecture course and tool summaries
  - Weekly exercise tasks
  - Infographics with basic information of each city
  - Quiz question for each tool
  - Additional reading material
  - Interviews with experts
  - Archive of lecture recordings
  - Reading material will be provided throughout the semester.

**Literature**

- The Swiss cadastral system (“Amtliche Vermessung”) as well as a number of international systems in developed as well as in developing countries are discussed.
- The importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples.
- Origin and purpose of cadastral systems
  - Importance of documentation of property information as a basis for economic development
  - Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)
  - Importance of cadastral systems for societal prosperity due to the impact on the economy, society and the environment.
- Contribution of the cadastre to the achievement of the UN SDGs on gender equality, poverty and food security.

- Swiss cadastral system
  - Legal basis
  - Organisation
  - Technical implementation
  - Quality and integrity assurance
  - Profession
  - Embedding cadastral data in the national spatial data infrastructure

- Contribution of cadastral systems as spatial reference data to the digital transformation of the society.
- International trends, developments and initiatives to strengthen property rights, 3D cadastral system (above and below ground)

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies fostered
Problem-solving fostered

Social Competencies

Cooperation and Teamwork fostered
Customer Orientation fostered
Sensitivity to Diversity fostered

Personal Competencies

Critical Thinking fostered

Electives ETH Zurich

Course Catalogue of ETH Zurich

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

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<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>101-0031-AAL</td>
<td>Systems Engineering</td>
<td>E-</td>
<td>3 credits</td>
<td>9R</td>
<td>B. T. Adey</td>
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</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

- Systems Engineering is a way of thinking that helps engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms.
- This course provides an overview of the main principles of Systems Engineering, and includes an introduction to the use of operations research methods in the determination of optimal systems.

Objective

The world’s growing population, changing demographics, and changing climate pose formidable challenges to humanity’s ability to live sustainably. Ensuring that humanity can live sustainably requires accommodating Earth’s growing and changing population through the provision and operation of a sustainable and resilient built environment. This requires ensuring excellent decision-making as to how the built environment is constructed and modified.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions to complex systems.

More specifically upon completion of the course, you will have gained insight into:

- how to structure the large amount of information that is often associated with attempting to modify complex systems
- how to set goals and define constraints in the engineering of complex systems
- how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking
- how to compare multiple possible solutions over time with differences in the temporal distribution of costs and benefits and uncertainty as to what might happen in the future
- how to carry out a step back from the numbers and qualitatively evaluate the possible solutions in light of the bigger picture
- the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.

Content

This is a self-study course, there are no lectures or help sessions. A Moodle page with the relevant literature, study materials, and course information is provided. For questions regarding course content or administration, students may approach the lecturers/teaching assistants.

Lecture notes

The script for the original course is in German. The English material that can be used for the self-study course is:

2 Books (provided as PDFs):

2 exams from previous semesters (2017 and 2021) for practice, with solutions provided.
### Competencies

#### Subject-specific Competencies

<table>
<thead>
<tr>
<th>Concepts and Theories</th>
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<tr>
<td>Techniques and Technologies</td>
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#### Method-specific Competencies

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<tr>
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<tr>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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#### Social Competencies

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<th>Communication</th>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
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<tr>
<td>Self-presentation</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
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<tr>
<td>Negotiation</td>
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#### Personal Competencies

<table>
<thead>
<tr>
<th>Adaptability and Flexibility</th>
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<tbody>
<tr>
<td>Creative Thinking</td>
<td>fostered</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
<td>Self-direction and Self-management</td>
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</table>

### Project Management

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

#### Abstract

General introduction to the development, the life cycle and the characteristics of projects. Introduction to and experience with the methods and tools to help with the preparation, evaluation, organisation, planning, controlling and completion of projects.

#### Objective

To introduce the methods and tools of project management. To impart knowledge in the areas of project organisation and structure, project planning, resource management, project controlling and on team leadership and team work.

#### Content

- From strategic planning to implementation (Project phases, goals, constraints, and feasibility)
- Project leadership (Leadership, Teams)
- Project organization (Structure)
- Project planning (Schedule, cost and resource planning)
- Project controlling
- Risk and Quality Management
- Project completion

#### Literature

Material that can be used for the self-study course is:

- 2 Books:
  - Shtub, Bard and Globerson, 2nd ed. Chapters 1, 6-11 (provided as PDFs)
  - Nicholas and Steyn, 4th ed., Chapters 1, 5-15 (Available online)

- 2 exams from previous semesters (2012 fall and spring) for practice, with solutions provided.

### Spatial Planning and Landscape Development

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

#### Abstract

The lecture introduces into the main-features of spatial planning. Attended will be the subjects of planning as a national responsibility, instruments of spatial planning, techniques for problem solving in spatial planning and the Swiss concept for regional planning.

#### Objective

- To get to know the interaction between the community and our living space and their resulting conflicts.
- Link theory and practice in spatial planning.
- To get to know instruments and facilities to process problems in spatial planning.

### Transport Basics

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

#### Abstract

- Introduction to the fundamentals of transportation
- Developing an understanding of the interactions between land use and transportation
- Introduction to the dynamics of transport systems: daily patterns and historical developments

#### Objective

Introduction to the fundamentals of transportation.
### Content
- Accessibility
- Equilibrium in transport networks
- Fundamental transport models
- Traffic flow and control
- Vehicle dynamics on rail and road
- Transport modes and supply patterns
- Time tables

### Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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### Spatial Development and Infrastructure Systems Master - Key for Type

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<th>Key</th>
<th>Type</th>
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<tbody>
<tr>
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<td>Eligible for credits</td>
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<td>Z</td>
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### Key for Hours

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<td>U</td>
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<td>K</td>
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### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
First Year Compulsory Courses

First Year Examination Block 1

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<td>401-0151-00L</td>
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<td>5</td>
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<td>V. C. Gradinaru</td>
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<tr>
<td></td>
<td>Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decomposition, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.</td>
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<td>Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte</td>
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<td>eigenes Aufschrieb und K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, S. Auflage 2002</td>
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252-0025-01L Discrete Mathematics

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</tr>
<tr>
<td></td>
<td>Content: Mathematical reasoning and proofs, abstraction, Sets, relations (e.g. equivalence and order relations), functions, (un-)countability, number theory, algebra (groups, rings, fields, polynomials, subalgebras, morphisms), logic (propositional and predicate logic, proof calculi).</td>
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<td>The primary goals of this course are (1) to introduce the most important concepts of discrete mathematics, (2) to understand and appreciate the role of abstraction and mathematical proofs, and (3) to discuss a number of applications, e.g. in cryptography, coding theory, and algorithm theory.</td>
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252-0856-00L Computer Science

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<td>6</td>
<td>2V+2U+2P</td>
<td>F. Friedrich Wicker, R. Sasse</td>
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<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.</td>
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<td>Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens &quot;behind the scenes&quot; when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.</td>
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<tr>
<td></td>
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<tr>
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<td>The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.</td>
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<td>Lecture slides and all other material will be made available for download on the course web page.</td>
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<td>Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010</td>
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<td></td>
<td>Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000</td>
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First Year Examination Block 2

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<td>8</td>
<td>4V+3U</td>
<td>F. Ziltener</td>
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<td>Reelle und komplexe Zahlen, Grenzwerte, Folgen, Reihen, Potenzreihen, stetige Abbildungen, Differential- und Integralechnung einer Variablen, Einführung in gewöhnliche Differentialgleichungen</td>
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<td>Einführung in die Grundlagen der Analysis</td>
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<td>Christian Blatter: Ingenieur-Analyse (Kapitel 1-4)</td>
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<td>Christian Blatter, Analysis I.</td>
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Abstract
Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.

Objective
The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

Content
Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids)
Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).

Literature
Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

402-0043-00L Physics I O 4 credits 3V+1U R. Grange

Abstract
Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.

Objective
The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

Content
Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids)
Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).

Lecture notes
The lecture follows the book "Physics" by Paul A. Tipler.

Literature
Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered
Method-specific Competencies
Problem-solving fostered
Personal Competencies
Critical Thinking fostered

401-0353-00L Analysis 3 O 4 credits 2V+2U F. Ziltener

Abstract
In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.

Objective
The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

Content
1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)
2.) Quasilinear first order PDEs
- Solution with the method of characteristics
- Conservation laws
3.) Hyperbolic PDEs
- Wave equation
- d'Alembert formula in (1+1)-dimensions
- Method of separation of variables
4.) Parabolic PDEs
- Heat equation
- Maximum principle
- Method of separation of variables
5.) Elliptic PDEs
- Laplace equation
- Maximum principle
- Method of separation of variables
- Variational method

Literature

Prerequisites / notice
Prerequisites: Analysis I and II, Fourier series (Complex Analysis)

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

401-0647-00L Introduction to Mathematical Optimization O 5 credits 2V+1U D. Adjashvili

Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.
Objective
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Literature
Information about relevant literature will be given in the lecture.

Prerequisites / notice
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

401-2673-00L Numerical Methods for CSE

Abstract
The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.

Objective
* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently

Content
* Computing with Matrices and Vectors
* Direct Methods for linear systems of equations
* Least Squares Techniques
* Data Interpolation and Fitting
* Iterative Methods for non-linear systems of equations
* Filtering Algorithms
* Approximation of Functions
* Numerical Quadrature

Lecture notes
Lecture materials (PDF documents and codes) will be made available to the participants through the course web page, whose address will be announced in the beginning of the course.

Literature
M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002
P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

Prerequisites / notice
The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Knowledge of C++ is taken for granted.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Block G2

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<td>401-2813-00L</td>
<td>Programming Techniques for Scientific Simulations I</td>
<td>O</td>
<td>5</td>
<td>4G</td>
<td>R. Käppeli</td>
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<td>Students in the Master's Degree Programme in Computational Science and Engineering must enroll only if this course unit is an additional requirement.</td>
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</tbody>
</table>

Abstract
This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.

Objective
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

252-0061-00L Systems Programming and Computer Architecture

Abstract
Introduction to systems programming. C and assembly language, floating point arithmetic, basic translation of C into assembler, compiler optimizations, manual optimizations. How hardware features like superscalar architecture, exceptions and interrupts, caches, virtual memory, multicore processors, devices, and memory systems function and affect correctness, performance, and optimization.

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<tr>
<th>Number</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0061-00L</td>
<td>Systems Programming and Computer Architecture</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>A. Klimovic, T. Roscoe</td>
</tr>
</tbody>
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Abstract

Literature

Prerequisites / notice

Competencies

Block G2

<table>
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<tr>
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</table>

Abstract

Objective

Competencies
Objective

The course objectives are for students to:

1. Develop a deep understanding of, and intuition about, the execution of all the layers (compiler, runtime, OS, etc.) between programs in high-level languages and the underlying hardware: the impact of compiler decisions, the role of the operating system, the effects of hardware on code performance and scalability, etc.

2. Be able to write correct, efficient programs on modern hardware, not only in C but high-level languages as well.

3. Understand Systems Programming as a complement to other disciplines within Computer Science and other forms of software development.

This course does not cover how to design or build a processor or computer.

Content

This course provides an overview of "computers" as a platform for the execution of (compiled) computer programs. This course provides a programmer's view of how computer systems execute programs, store information, and communicate. The course introduces the major computer architecture structures that have direct influence on the execution of programs (processors with registers, caches, other levels of the memory hierarchy, supervisor/kernel mode, and I/O structures) and covers implementation and representation issues only to the extend that they are necessary to understand the structure and operation of a computer system.

The course attempts to expose students to the practical issues that affect performance, portability, security, robustness, and extensibility. This course provides a foundation for subsequent courses on operating systems, networks, compilers and many other courses that require an understanding of the system-level issues. Topics covered include: machine-level code and its generation by optimizing compilers, address translation, input and output, trap/event handlers, performance evaluation and optimization (with a focus on the practical aspects of data collection and analysis).

Lecture notes

- C programming
- Integers
- Pointers and dynamic memory allocation
- Basic computer architecture
- Compiling C control flow and data structures
- Code vulnerabilities
- Implementing memory allocation
- Linking
- Floating point
- Optimizing compilers
- Architecture and optimization
- Caches
- Exceptions
- Virtual memory
- Multicore
- Devices

Literature

The course is based in part on "Computer Systems: A Programmer's Perspective" (3rd Edition) by R. Bryant and D. O'Hallaron, with additional material.

Prerequisites / notice

252-0029-00L  Parallel Programming
252-0028-00L  Design of Digital Circuits

Block G3

All course units within Block G3 are offered in the spring semester.

Block G4

All course units within Block G4 are offered in the spring semester.

Core Courses

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>252-0232-00L</td>
<td>Software Engineering</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>M. Lüthi, M. Schwerhoff, H. Lehner</td>
</tr>
</tbody>
</table>

Abstract

This course introduces both theoretical and applied aspects of software engineering. It covers:

- Software Architecture
- Informal and formal Modeling
- Design Patterns
- Software Engineering Principles
- Code Refactoring
- Program Testing

Objective

The course has two main objectives:

- Obtain an end-to-end (both, theoretical and practical) understanding of the core techniques used for building quality software.
- Be able to apply these techniques in practice.

Content

While the lecture will provide the theoretical foundations for the various aspects of software engineering, the students will apply those techniques in project work that will span over the whole semester - involving all aspects of software engineering, from understanding requirements over design and implementation to deployment and change requests.

Lecture notes

no lecture notes

Literature

Will be announced in the lecture
### Design of Parallel and High-Performance Computing

**Number:** 263-2800-00L

**Title:** Design of Parallel and High-Performance Computing

**Type:** W

**ECTS:** 9 credits

**Hours:** 2V+2U+4A

**Lecturers:** T. Hoefler

**Abstract:**
Advanced topics in parallel and high-performance computing.

**Objective:**
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

**Content:**
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites / notice:**
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

---

### Astrophysics

#### Theoretical Astrophysics (University of Zurich)

**Number:** 401-7851-00L

**Title:** Theoretical Astrophysics (University of Zurich)

**Type:** W

**ECTS:** 10 credits

**Hours:** 4V+2U

**Lecturers:** University lecturers

**Abstract:**
This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

**Content:**
This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

**Prerequisites / notice:**
This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

**Prerequisites:**
Introduction to Astrophysics
Mathematical Methods for the Physicist
Quantum Mechanics
(All preferred but not obligatory)

**Prior Knowledge:**
Mechanics
Quantum Mechanics and atomic physics
Thermodynamics
Fluid Dynamics
Electrodynamics

#### Computational Astrophysics (University of Zurich)

**Number:** 401-7855-00L

**Title:** Computational Astrophysics (University of Zurich)

**Type:** W

**ECTS:** 6 credits

**Hours:** 2V

**Lecturers:** L. M. Mayer

**Abstract:**
Mind the enrolment deadlines at UZH:

**Prerequisites / notice:**
This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

**Prerequisites:**
Introduction to Astrophysics
Mathematical Methods for the Physicist
Quantum Mechanics
(All preferred but not obligatory)

**Prior Knowledge:**
Mechanics
Quantum Mechanics and atomic physics
Thermodynamics
Fluid Dynamics
Electrodynamics

**Objective:**
Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes
### Physics of the Atmosphere

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<tbody>
<tr>
<td>701-0023-00L</td>
<td><strong>Atmosphere</strong></td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>E. Fischer, U. Lohmann</td>
</tr>
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</table>

#### Objective
- to explain the physical structure and chemical composition of the atmosphere
- to qualitatively describe and understand the fundamental physical and chemical process in the atmosphere
- to explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.

#### Content
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

#### Literature

### Chemistry

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<th>Number</th>
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<tbody>
<tr>
<td>529-0004-01L</td>
<td><strong>Classical Simulation of (Bio)Molecular Systems</strong></td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>P. H. Hünenberger, J. Dolenc, S. Riniker</td>
</tr>
</tbody>
</table>

#### Abstract
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

#### Objective
Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

#### Content
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

#### Literature
See: www.csms.ethz.ch/education/CSBMS

#### Prerequisites / notice
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

#### Competencies
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Communication fostered
- Personal Competencies: Creative Thinking fostered

### Quantum Mechanics I

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<tbody>
<tr>
<td>402-0205-00L</td>
<td><strong>Quantum Mechanics I</strong></td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U</td>
<td>M. Krstic Marinkovic</td>
</tr>
</tbody>
</table>

#### Abstract

#### Objective
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.
The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.

Lecture notes
Auf Moodle

Literature
G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Fluid Dynamics

Number Title Type ECTS Hours Lecturers
151-0709-00L Stochastic Methods for Engineers and Natural Scientists W 4 credits 4G D. W. Meyer-Massetti

Abstract
The course provides an introduction into stochastic methods that are applicable for the description, treatment, and modeling of systems that are subject to uncertainties or that respond to parameter changes in a chaotic manner. Corresponding systems may arise in fluid dynamics, structural mechanics, biology, electrical engineering as well as other areas.

Objective
By the end of the course you will be familiar with a range of mathematical/statistical tools that enable a quantitative treatment of problems that involve uncertainties.

Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation
- Kalman filters (classical and ensemble-based)
- Statistical tests for means and goodness-of-fit

Lecture notes
Detailed lecture notes will be provided.

Literature
Some textbooks related to the material covered in the course:

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed

Personal Competencies
Adaptability and Flexibility assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-direction and Self-management assessed

151-0125-00L Hydrodynamics and Cavitation W 4 credits 3G O. Supponen

Abstract
This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

Objective
The main learning objectives of this course are:
1. Identify and describe dominant effects in liquid fluid flows through physical modelling.
2. Identify and predict the onset of hydrodynamic instabilities.
3. Describe acoustic wave behaviour in liquids.
4. Explain tension, nucleation and phase-change in liquids.
5. Predict the behaviour of a gas bubble subject to changes in surrounding liquid pressure.
6. Describe hydrodynamic cavitation and its consequences in physical terms.
7. Recognise experimental techniques and industrial and medical applications for cavitation.
8. Read and evaluate research papers on recent research on cavitation and bubble dynamics and communicate the content orally to a multidisciplinary audience.
Content
The course gives an overview on the following topics: basics of hydrodynamics, capillarity, hydrodynamic instabilities, liquid fragmentation, Acoustics in liquids, tension in liquids, phase change. Cavitation and bubble dynamics: single bubbles (nucleation, dynamics, collapse), bubble clouds and cavitating flows. Industrial applications and measurement techniques.

Lecture notes
Class notes and handouts

Literature
Literature will be provided in the course material.

Prerequisites / notice
Fluid dynamics I & II or equivalent

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork fostered

Personal Competencies
- Creative Thinking fostered
- Critical Thinking assessed

Systems and Control

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<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
</tbody>
</table>

Abstract
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Content

Literature

Prerequisites / notice
Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

Robotics

Only one of the two course units 263-5902-00L Computer Vision resp. 227-0447-00L Image Analysis and Computer Vision may be recognised for credits for the overall (CSE Bachelor and Master) study programmes.

Only one of the two course units 263-5210-00L Probabilistic Artificial Intelligence resp. 252-0535-00L Advanced Machine Learning may be recognised for credits in the field of specialisation 'Robotics' for the overall (CSE Bachelor and Master) study programmes. However, the other course unit may be recognised for a different category.

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Abstract
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Objective
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Content

Literature

Prerequisites / notice
Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

Robotics

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<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
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Abstract
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Content

Literature

Prerequisites / notice
Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.
Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice
This is an advanced level course that requires some basic background in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://tas.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D’Andrea

Abstract
Introduction to Dynamic Programming and Optimal Control.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2181 of 2667
### Robotics (continued)

Only one of the two course units 263-5902-00L Computer Vision resp. 227-0447-00L Image Analysis and Computer Vision may be recognised for credits for the overall (CSE Bachelor and Master) study programmes.

Only one of the two course units 263-5210-00L Probabilistic Artificial Intelligenz resp. 252-0535-00L Advanced Machine Learning may be recognised for credits in the field of specialisation 'Robots' for the overall (CSE Bachelor and Master) study programmes. However, the other course unit may be recognised for a different category.

For the category assignment take contact with the Study Administration (www.math.ethz.ch/studiensekretariat).

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>263-5902-00L</td>
<td>Computer Vision</td>
<td>W</td>
<td>8</td>
<td>3V+1U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.</td>
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<td>Objective</td>
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<td>The objectives of this course are:</td>
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<td></td>
<td>1. To introduce the fundamental problems of computer vision.</td>
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<td>2. To introduce the main concepts and techniques used to solve those.</td>
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<td>3. To encourage participants to implement solutions for reasonably complex problems.</td>
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<td>4. To enable participants to make sense of the computer vision literature.</td>
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<td>Content</td>
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<td></td>
<td>Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition</td>
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<td>Prerequisites / notice</td>
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<tr>
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<td>The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Basics in Fluid Dynamics.</td>
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<tr>
<td>263-5210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>A. Krause</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.</td>
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<td></td>
<td>Objective</td>
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<td></td>
<td>How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit &quot;intelligent&quot; behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.</td>
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<td>Content</td>
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<td>- Probability</td>
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<td>- Probabilistic inference (variational inference, MCMC)</td>
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<td>- Bayesian learning (Gaussian processes, Bayesian deep learning)</td>
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<td>- Probabilistic planning (MDPs, POMDPs)</td>
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<td>- Multi-armed bandits and Bayesian optimization</td>
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<td>- Reinforcement learning</td>
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<td>Prerequisites / notice</td>
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<td></td>
<td>Solid basic knowledge in statistics, algorithms and programming.</td>
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<td>The material covered in the course &quot;Introduction to Machine Learning&quot; is considered as a prerequisite.</td>
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<td>Media and Digital Technologies</td>
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### Physics

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<tr>
<td>402-0809-00L</td>
<td>Introduction to Computational Physics</td>
<td>W</td>
<td>8</td>
<td>2V+2U</td>
<td>A. Adelmann</td>
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<tr>
<td>Abstract</td>
<td>This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.</td>
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<tr>
<td>Objective</td>
<td>Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.</td>
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<tr>
<td>Content</td>
<td>Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes and slides are available online and will be distributed if desired.</td>
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<td>Literature</td>
<td>Literature recommendations and references are included in the lecture notes.</td>
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<td>Prerequisites / notice</td>
<td>Lecture and exercise lessons in english, exams in German or in English</td>
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<td>402-0205-00L</td>
<td>Quantum Mechanics I</td>
<td>W</td>
<td>8</td>
<td>3V+2U</td>
<td>M. Krstic Marinkovic</td>
</tr>
<tr>
<td>Objective</td>
<td>Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.</td>
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<tr>
<td>Content</td>
<td>The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.</td>
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<td>Lecture notes</td>
<td>Auf Moodle</td>
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<td>G. Baym, Lectures on Quantum Mechanics</td>
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<td></td>
<td>E. Merzbacher, Quantum Mechanics</td>
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<td>L.I. Schiff, Quantum Mechanics</td>
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<td></td>
<td>R. Feynman and A.R. Hibbs. Quantum Mechanics and Path Integrals</td>
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<td></td>
<td>J.J. Sakurai: Modern Quantum Mechanics</td>
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<td></td>
<td>A. Messiah: Quantum Mechanics I</td>
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<td>S. Weinberg: Lectures on Quantum Mechanics</td>
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<td>Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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### Computational Finance

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<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4</td>
<td>3V+2U</td>
<td>D. Possamaï</td>
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<tr>
<td>Abstract</td>
<td>First introduction to main modelling ideas and mathematical tools from mathematical finance. This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest.. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.</td>
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<tr>
<td>Objective</td>
<td>This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest.. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.</td>
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Topics to be covered include

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

Lecture notes See information on course homepage

Prerequisites / notice Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitsrechnung".)

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Potter book. If these pose problems, you will have a hard time during the course. So be prepared.

Competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
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<tr>
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<td>Analytical Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Techniques and Technologies</td>
<td>Decision-making</td>
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<td>Problem-solving</td>
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401-4657-00L Numerical Solution of Stochastic Ordinary Differential Equations

W 6 credits 3V+1U C. Schwab

Abstract

This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective

The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content

Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes

There will be English, typed lecture notes for registered participants in the course.

Literature

P. E. Kloeden and E. Platen:
Numerical Solution of Stochastic Differential Equations.

Bertoin, Jean:
Lévy processes.
Cambridge Tracts in Mathematics, 121.
Cambridge University Press,

Cont, Rama; Tankov, Peter:
Financial modelling with jump processes.
Chapman & Hall/CRC Financial Mathematics Series,

Prerequisites / notice

Prerequisites:

Mandatory:
Probability and measure theory,
basic numerical analysis and
basics of MATLAB/Python programming.

a) mandatory courses:
Measure - and Probability Theory I
as covered in courses:
ETH 401-2283-00L Analysis III (Measure Theory)
UZH Kursmodul 10498 Hauptvorlesung: Mass- und Integrationstheorie

b) recommended courses:
Stochastic Processes I

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### Electromagnetics

#### Number Title

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<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>J. Smajic</td>
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#### Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

#### Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

#### Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

### Geophysics

#### Recommended combinations:
- Subject 1 + Subject 2
- Subject 1 + Subject 3
- Subject 2 + Subject 3
- Subject 3 + Subject 4
- Subject 5 + Subject 6 + Subject 8
- Subject 4 + Subject 5
- Subject 7 + Subject 8

#### Geophysics: Subject 1

#### Number Title

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<td>651-4007-00L</td>
<td>Continuum Mechanics</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>T. Gerya</td>
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#### Abstract
In this course, students learn crucial partial differential equations (conservation laws) that are applicable to any continuum including the Earth’s mantle, core, atmosphere and ocean. The course will provide step-by-step introduction into the mathematical structure, physical meaning and analytical solutions of the equations. The course has a particular focus on solid Earth applications.

#### Objective
The goal of this course is to learn and understand few principal partial differential equations (conservation laws) that are applicable for analysing and modelling of any continuum including the Earth’s mantle, core, atmosphere and ocean. By the end of the course, students should be able to write, explain and analyse the equations and apply them for simple analytical cases. Numerical solving of these equations will be discussed in the Numerical Modelling I and II course running in parallel.
Weeks 1, 2: The continuity equation
Exercise: Computing the divergence of velocity field.

Weeks 3, 4: Density and gravity
Exercises: Computing density, thermal expansion and compressibility from an equation of state. Derivation of gravitational acceleration and its divergence from gravitational potential.

Weeks 5, 6: Stress and strain
Exercises: Analysing strain rate tensor for solid body rotation. Computing stress invariants

Weeks 7, 8: The momentum equation
Exercises: Deriving momentum equation. Computing velocity for magma flow in a channel.

Week 9: Viscous rheology of rocks
Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth’s interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws.
Exercise: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

Weeks 10: The heat conservation equation
Exercises: Computing heat fluxes. Deriving equation for steady state temperature profile in a magma channel.

Week 11, 12: Elasticity and plasticity
Exercise: Compute viscoelastic stress evolution.


GRADING will be based on homeworks (1/3) and oral exam (2/3).

Lecture notes
Script and Exam questions are available by request: tgerya@ethz.ch

Literature

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed
Problem-solving assessed

Geophysics: Subject 2

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<thead>
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<td>651-4241-00L</td>
<td>Numerical Modelling I and II: Theory and Applications</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>T. Gerya</td>
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</table>

Abstract
In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasize a hands-on learning approach rather than extensive theory.

Objective
The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasize a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.
Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity with stream function/vorticity formulation.


Weeks 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


Week 14: Final project description for slab breakoff modeling.

GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Text: 02.07.2024 12:39
Autumn Semester 2024
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The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Content

Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label “Systems Biology”, focuses on how networks, which are more than the mere sum of their parts’ properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Lecture notes

http://www.csb.ethz.ch/education/lectures.html

Literature


Courses Offered in the Spring Semester

Geophysics: Subject 6

Geophysics: Subject 7

Geophysics: Subject 8

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4273-00L</td>
<td>Numerical Modelling in Fortran</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>P. Tackley</td>
</tr>
</tbody>
</table>

Abstract

This course gives an introduction to numerical methods for the analysis of complex biological networks. It covers topics such as: dynamic systems, stochastic processes, and computational methods. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. Hands-on approach will be emphasized rather than abstract concepts.

Objective

This course aims to provide an introduction to Fortran programming, suitable for students who have only minimal programming experience. A hands-on approach will be emphasized rather than abstract concepts.

Lecture notes

See http://jupiter.ethz.ch/~git/FORTRAN/FortranClass.html

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
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</table>

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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
</tbody>
</table>

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Lecture notes

http://www.csb.ethz.ch/education/lectures.html

Literature


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0706-00L</td>
<td>Spatio-Temporal Modelling in Biology</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Iber</td>
</tr>
</tbody>
</table>

Abstract

This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on mechanisms and concepts, but mathematical and numerical techniques are introduced as required. Biological examples discussed in the course provide an introduction to key concepts in developmental biology.

Objective

Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical systems, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

Content

1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary
Virtual Reality not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, entering collaborations between enterprises, the interaction of the human user with the digital environment, or the use of augmented reality systems.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

**Electives**

In the 'electives' subcategory, at least two course units must be successfully completed.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0317-00L</td>
<td>Visualization, Simulation and Interaction - Virtual Reality II</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Kunz</td>
</tr>
</tbody>
</table>

Abstract

This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective

Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems.

The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content

The handout is available in German and English.

Lecture notes

"Visualization, Simulation and Interaction - Virtual Reality II" is recommended, but not mandatory.

Prerequisites

No prerequisites.

Competencies

- Subject-specific Competencies: Concepts and Theories, assessed
- Method-specific Competencies: Analytical Competencies, assessed
- Social Competencies: Communication, assessed
- Personal Competencies: Creative Thinking, assessed

151-0833-00L

**Applied Finite Element Analysis**

Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUUS is introduced to investigate real engineering problems.
Objective
The goal of the lecture is to provide the students with the fundamentals of the nonlinear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:
- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

Content
- Introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

Lecture notes
Lecture slides

Literature

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151-0529-00L Nonlinear FEA

Objective
To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.

Content
1. Introduction: Various sources of nonlinearities and implications for FEA.

Lecture notes
Lecture notes will be provided. However, students are encouraged to take their own notes.

Prerequisites / notice
Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

263-2800-00L Design of Parallel and High-Performance Computing

Objective
Advanced topics in parallel and high-performance computing.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallel Programming" and "Algorithmen und Datenstrukturen" or equivalent courses.

227-0102-00L Discrete Event Systems

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.

Content
1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes
Textbook and all further documents in English.

Literature
This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/ for details.
This course acquaints students with core knowledge in computer graphics, image processing, multimedia and computer vision. Topics include: Graphics pipeline, perception and camera models, transformation, shading, global illumination, texturing, sampling, filtering, image representations, image and video compression, edge detection and optical flow.

**Objective**
This course provides an in-depth introduction to the core concepts of computer graphics, image processing, multimedia and computer vision. The course forms a basis for the specialization track Visual Computing of the CS master program at ETH.

**Content**
Course topics will include: Graphics pipeline, perception and color models, camera models, transformations and projection, projections, lighting, shading, global illumination, texturing, sampling theorem, Fourier transforms, image representations, convolution, linear filtering, diffusion, nonlinear filtering, edge detection, optical flow, image and video compression.

In theoretical and practical homework assignments students will learn to apply and implement the presented concepts and algorithms.

**Lecture notes**
A script will be handed out for a part of the course. Copies of the slides will be available for download. We will also provide a detailed list of references and textbooks.

**Literature**

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### 252-0543-01L Computer Graphics

<table>
<thead>
<tr>
<th>Abstract</th>
<th>This course covers fundamental and advanced concepts of modern computer graphics. Students will learn the fundamentals of digital scene representations, advanced physically-based light transport algorithms for generating photorealistic images from these scene representations, and inverse rendering methods for recovering digital scene representations from captured images.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>At the end of the course, the students will be able to build a rendering system based on path-tracing algorithms. The students will learn the principles of physically-based rendering and computer graphics. In addition, the course is intended to stimulate the student's curiosity to explore the field of computer graphics in subsequent classes or on their own.</td>
</tr>
<tr>
<td>Content</td>
<td>We will begin with an introduction to light emission and radiometric quantities, followed by an exploration of geometry representations and texture mapping. Next, we will mathematically formulate the physics of light transport and appearance modeling. Subsequently, we will introduce relevant concepts from Monte Carlo integration and develop path-tracing algorithms to solve these equations by simulating light transport for direct and global illumination due to hard surfaces and participating media, such as fog, smoke, and translucent objects. Moreover, we will present techniques for significantly improving path-tracing efficiency, including importance sampling, multiple importance sampling, stratified sampling, denoising, and acceleration data structures. The course lectures will conclude with an overview of image-based capture and rendering methods. Topics covered will include geometry reconstruction, material acquisition, differentiable rendering, and image-based rendering.</td>
</tr>
<tr>
<td>Literature</td>
<td>Books: Physically Based Rendering: From Theory to Implementation High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting Multiple view geometry in Computer Vision</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, and the Visual Computing course are recommended.</td>
</tr>
<tr>
<td>Lecture notes</td>
<td>no</td>
</tr>
</tbody>
</table>

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### 252-0546-00L Physically-Based Simulation in Computer Graphics

<table>
<thead>
<tr>
<th>Abstract</th>
<th>This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.</td>
</tr>
<tr>
<td>Content</td>
<td>The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++, Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.</td>
</tr>
</tbody>
</table>

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### 252-0834-00L Information Systems for Engineers

<table>
<thead>
<tr>
<th>Abstract</th>
<th>This course provides the basics of relational databases from the perspective of the user. We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>The course also covers support for data cubes (analytics).</td>
</tr>
<tr>
<td>Literature</td>
<td>Books:</td>
</tr>
</tbody>
</table>
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL
6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).

(If it is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
**401-3627-00L High-Dimensional Statistics**
*W 4 credits 2V not available*

**Abstract**
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

**Objective**
Knowledge of methods and basic theory for high-dimensional statistical inference

**Content**
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and 11-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

**Literature**

**Prerequisites / notice**
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

---

**401-4623-00L Time Series Analysis**
*W 4 credits 2G F. Balabdaoui*

**Abstract**
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

**Objective**
The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.

**Content**
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:

- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

**Literature**
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

**Prerequisites / notice**
Basic knowledge in probability and statistics

---

**401-3901-00L Linear & Combinatorial Optimization**
*W 10 credits 4V+2U R. Zenklusen*

**Abstract**
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**

**Prerequisites / notice**
Solid background in linear algebra.

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**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
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<td></td>
<td>Problem-solving</td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
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<td>Negotiation</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
</tr>
</tbody>
</table>
The lecture "Applied Computer Architecture" gives technical and corporate insights in innovative Computer Systems/Architectures (CPU, Adaptability and Flexibility).

T. Delbrück fostered

**Analytical Competencies**

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on understanding of the characteristics of neuromorphic circuit elements.

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

**Communication**

W

Classical Mechanics

A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

M. Gaberdie

**Neuromorphic Engineering I**

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module IN404 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

**Abstract**

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective**

Understanding the characteristics of neuromorphic circuit elements.

**Content**

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

**Literature**

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

**Prerequisites / notice**

Particular: The course is highly recommended for those who intend to take the spring semester course 'Neuromorphic Engineering II', that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

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**Additional Electives from the Fields of Specialization (CSE Master)**

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**Data:** 02.07.2024 12:39  
**Autumn Semester 2024**  
**Page 2196 of 2667**
**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
651-4053-05L | **Boundary Layer Meteorology** | W | 4 credits | 3G | M. Rotach, P. Calanca

**Abstract**
The Planetary Boundary Layer (PBL) constitutes the lower part of the atmosphere, is characterized by turbulent mixing and ensures the exchange of energy, mass and momentum between the Earth’s surface and the atmosphere. The course provides the theoretical background for understanding the structure and dynamics of the PBL. Idealized concepts are reviewed and contrasted to real world applications.

**Objective**
- Students are able to:
  - Name the basic approaches needed to describe planetary boundary layer flows and associated turbulent exchange processes.
  - Apply these concepts to answer comprehension questions and solve simple problems related to the structure and dynamics of the PBL.
  - Independently judge the applicability of learned concepts and tools to real-world situations.

**Content**
- Introduction
- PBL structure and stability
- Turbulence and turbulent transport
- Scaling and similarity theory
- Spectral characteristics
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Rough surfaces and the roughness sublayer
- Complex terrain

**Lecture notes**
available (i.e. in English)

**Literature**

**Prerequisites / notice**
Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
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<td>Problem-solving</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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</tbody>
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701-1221-00L | **Dynamics of Large-Scale Atmospheric Flow** | W | 4 credits | 2V+1U | H. Wernli, J. Riboli

**Abstract**
This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

**Objective**
Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

**Content**
Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

**Lecture notes**
Dynamics of large-scale atmospheric flow

**Literature**
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

**Prerequisites / notice**
Physics I, II, Environmental Fluid Dynamics

<table>
<thead>
<tr>
<th>Competencies</th>
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<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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</table>

529-0003-01L | **Advanced Quantum Chemistry** | W | 6 credits | 3G | M. Reiher, T. Weymuth

**Abstract**
Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer.
Examples are:
* Operators derived from principles of relativistic quantum mechanics
* Relativistic effects + methods of relativistic quantum chemistry
* Open-shell molecules + spin-density functional theory
* New electron-correlation theories

**Objective**
The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. Examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.

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## Content

1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group

## Lecture notes

A set of detailed lecture notes will be provided, which will cover the whole course.

## Literature

2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992

Note also the standard textbooks:
A) A. Szabo, N.S. Ostlund. Verlag, Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson
The course builds upon three parts:
I. Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II. Theoretical basis of statistical mechanics and kinetic equations.
III. Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory; Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow:
   Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   Relativistic fluid dynamics; flows with phase transitions.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

**636-0017-00L** Computational Biology

**Abstract**
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

**Objective**
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

**Content**
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS.

Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

**Lecture notes**
Lecture slides will be available on moodle.

**Literature**
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

**Prerequisites / notice**
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Personal Competencies
  - Creative Thinking
  - Critical Thinking

**Case Studies**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-3667-74L</td>
<td>Case Studies Seminar (Autumn Semester 2024)</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>V. C. Gradinaru, R. Hiptmair,</td>
</tr>
</tbody>
</table>
Invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list.

**Objective**

- actual techniques for the presentation of scientific results in a scientific talk
- awareness of actual questions in research and development in CSE related areas

**Content**

In the CSE Case Studies Seminar invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list (containing articles from, e.g., Nature, Science, Scientific American, etc.). If the underlying paper comprises more than 15 pages, two or three consecutive case studies presentations delivered by different students can be based on it. Consistency in layout, style, and contents of those presentations is expected.

Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

**Prerequisites / notice**

75% attendance and a short presentation on a published paper out of a list on or own some project are mandatory.

Students have to register their presentations online until the first Sunday of the semester on https://rw.ethz.ch/the-programme/case-studies.html

The student talks will be grouped by subject, so we'll decide the actual dates of the individual talks.

Students that realize that they will not fulfill this criteria have to contact the teaching staff or de-register before the end of semester from the Seminar if they want to avoid a "Fail" in their documents. Later de-registrations will not be considered.

**Competencies**

- **Subject-specific Competencies**
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- **Method-specific Competencies**
  - fostered

- **Social Competencies**
  - Communication
  - Cooperation and Teamwork

- **Personal Competencies**
  - Adaptable and Flexible
  - Creative Thinking
  - Critical Thinking
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

- **Decision-making**
  - fostered

- **Media and Digital Technologies**
  - fostered

- **Problem-solving**
  - fostered

- **Project Management**
  - fostered

**Science in Perspective**

- **Recommended Science in Perspective (Type B) for D-MATH**

**Bachelor’s Thesis**

If you wish to have recognised 402-2000-00L Scientific Works in Physics instead of 401-2000-00L Scientific Works in Mathematics (as allowed for the CSE programme), take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having passed the performance assessment.

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
402-2000-00L | Scientific Works in Physics | W | 0 credits | 0 | D. Kienzler

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
401-2000-00L | Scientific Works in Mathematics | O | 0 credits | 0 | D. Possamaï

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
401-2000-01L | Lunch Sessions – Thesis Basics for Mathematics | Z | 0 credits | 0 | Speakers

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
402-2000-00L | Scientific Works in Physics | W | 0 credits | 0 | D. Kienzler

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**Science in Perspective**

- **see Science in Perspective: Type A: Enhancement of Reflection Capability**

- **Recommended Science in Perspective (Type B) for D-MATH**

- **see Science in Perspective: Language Courses ETH/UZH**

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**Science in Perspective**

- **see Science in Perspective: Type A: Enhancement of Reflection Capability**

- **Recommended Science in Perspective (Type B) for D-MATH**

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**Bachelor’s Thesis**

If you wish to have recognised 402-2000-00L Scientific Works in Physics instead of 401-2000-00L Scientific Works in Mathematics (as allowed for the CSE programme), take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having passed the performance assessment.

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**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
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401-2000-01L | Lunch Sessions – Thesis Basics for Mathematics | Z | 0 credits | 0 | Speakers

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
402-2000-00L | Scientific Works in Physics | W | 0 credits | 0 | D. Kienzler

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**Science in Perspective**

- **see Science in Perspective: Type A: Enhancement of Reflection Capability**

- **Recommended Science in Perspective (Type B) for D-MATH**

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**Bachelor’s Thesis**

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401-2000-01L | Lunch Sessions – Thesis Basics for Mathematics | Z | 0 credits | 0 | Speakers

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
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402-2000-00L | Scientific Works in Physics | W | 0 credits | 0 | D. Kienzler

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**Science in Perspective**

- **see Science in Perspective: Type A: Enhancement of Reflection Capability**

- **Recommended Science in Perspective (Type B) for D-MATH**

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**Bachelor’s Thesis**

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**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
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401-2000-00L | Scientific Works in Mathematics | O | 0 credits | 0 | D. Possamaï

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
401-2000-01L | Lunch Sessions – Thesis Basics for Mathematics | Z | 0 credits | 0 | Speakers

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
402-2000-00L | Scientific Works in Physics | W | 0 credits | 0 | D. Kienzler

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**Science in Perspective**

- **see Science in Perspective: Type A: Enhancement of Reflection Capability**

- **Recommended Science in Perspective (Type B) for D-MATH**

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**Bachelor’s Thesis**

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**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
401-2000-00L | Scientific Works in Mathematics | O | 0 credits | 0 | D. Possamaï

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
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401-2000-01L | Lunch Sessions – Thesis Basics for Mathematics | Z | 0 credits | 0 | Speakers

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
402-2000-00L | Scientific Works in Physics | W | 0 credits | 0 | D. Kienzler

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**Science in Perspective**

- **see Science in Perspective: Type A: Enhancement of Reflection Capability**

- **Recommended Science in Perspective (Type B) for D-MATH**

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**Bachelor’s Thesis**

If you wish to have recognised 402-2000-00L Scientific Works in Physics instead of 401-2000-00L Scientific Works in Mathematics (as allowed for the CSE programme), take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having passed the performance assessment.
Abstract

The BSc thesis concludes the curriculum. In their BSc thesis, students should demonstrate their ability to carry out independent, structured scientific work. The purpose of the BSc thesis is to deepen knowledge in a certain subject and to bring students into closer contact with applications in an existing computational group. The BSc thesis requires approximately 420 hours of work.

Objective

In their BSc thesis students should demonstrate their ability to carry out independent, structured scientific work. The purpose is to deepen knowledge in a certain subject and to enable students to collaborate in an existing scientific group to take a computational approach to problems encountered in applications.

Prerequisites / notice

The supervisor responsible for the Bachelor thesis defines the task and determines the start and the submission date. The Bachelor thesis concludes with a written report. The Bachelor thesis is graded.

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<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>401-5650-00L</td>
<td>Zurich Colloquium in Applied and Computational Mathematics</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>R. Alaifari, H. Ammari, R. Hiptmair, S. Mishra, C. Schwab</td>
</tr>
</tbody>
</table>

Abstract

Research colloquium

Computational Science and Engineering Bachelor - Key for Type

O  Compulsory
W+  Eligible for credits and recommended
W  Eligible for credits

Key for Hours

V  lecture
G  lecture with exercise
U  exercise
S  seminar
K  colloquium

P  practical/laboratory course
A  independent project
D  diploma thesis
R  revision course / private study

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Computational Science and Engineering Master

Core Courses

In the 'core courses' subcategory, at least two course units must be successfully completed.

Only one of the two course units
263-5210-00L Probabilistic Artificial Intelligence resp.
252-0535-00L Advanced Machine Learning
may be recognised for credits as a core course. However, the other course unit may be recognised for a different category.

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<tbody>
<tr>
<td>401-4656-21L</td>
<td>AI in the Sciences and Engineering</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>S. Mishra</td>
</tr>
</tbody>
</table>

Abstract
AI is having a profound impact on science by accelerating discoveries across physics, chemistry, biology, and engineering. This course aims to present a highly topical selection of AI applications across these fields. Emphasis will be placed on using AI, particularly deep learning, to understand systems modelled by PDEs, and key scientific machine learning concepts and themes will be discussed.

Objective
Learning objectives:
- Aware of advanced applications of AI in the sciences and engineering
- Familiar with the design, implementation, and theory of these algorithms
- Understand the pros/cons of using AI and deep learning for science
- Understand key scientific machine learning concepts and themes

Content
A selection of the following topics will be presented in the lectures:
1. Key scientific tasks common to many scientific domains, such as simulation, inverse problems, equation discovery, design, and control problems, and issues with traditional methods for solving them
2. Physics-informed neural networks for solving forward, inverse and equation discovery problems related to PDEs
3. Neural operators, including Fourier neural operators and DeepONets, for learning efficient surrogate models, and their theoretical foundations
4. Differentiable scientific algorithms, neural differential equations, and the benefits of hybrid workflows
5. AI for symbolic regression and equation discovery
6. Applications of graph neural networks in science
7. Guest lectures on AI for chemistry and biology
8. Large language models and other Foundation models for scientific discovery

Lecture notes
Lecture slides, recordings, and tutorials will be available on Moodle.

Literature
All the material in the course is based on research articles written in last 1-3 years. The relevant references will be provided.

Prerequisites / notice
- An understanding of basic ML concepts including supervised learning, overfitting/underfitting, optimisation, and neural networks is required; you should understand the main concepts in the ETH 252-0220-00L Introduction to Machine Learning course (but note, completing this course is not a formal requirement)
- Familiar with PDEs and numerical methods for solving them
- Basic competence in Python and some practical familiarity with deep learning frameworks (e.g. PyTorch, TensorFlow, or Keras)

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered

252-0535-00L Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Autumn Semester 2024
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

**Lecture notes**
No lecture notes, but slides will be made available on the course webpage.

**Literature**

**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

**401-4671-00L Advanced Numerical Methods for CSE**

**Abstract**
This course will focus on teaching different advanced topics in numerical methods for science and engineering. The main aim would be to introduce novel algorithms and discuss their implementation.

**Objective**
- Ability to adapt the presented paradigms and algorithms to modified or new problems arising from applications in computational science and engineering.
- Ability to judge the scope, strengths and weaknesses of the numerical methods covered in this course and of methods derived from them.
- Skills in translating a high-level description of an algorithm into efficient code.

**Content**
The course will comprise three main chapters:

1. **The Boundary Element Method (BEM):**
   - It is a numerical method used to solve boundary value problems for linear PDEs. It focuses only on the boundary, rather than the entire volume of the domain to be modeled. [50%]

2. **Hierarchical Matrices (H-matrices):**
   - They are an efficient data structure used to approximate dense matrices with a hierarchical block structure, significantly reducing the computational and memory costs for operations like matrix multiplication and inversion. [25%]

3. **Hybrid Modeling:**
   - The technique combines multiple modeling techniques, such as physics-based models and data-driven approaches, to capitalize on the strengths of each method and improve the accuracy and efficiency of simulations or predictions in complex systems. [25%]

**Lecture notes**
Lecture material will be created during the course and will be made available.

**Prerequisites / notice**
- Familiarity with basic numerical methods (as taught in the course "Numerical Methods for CSE").
- Knowledge of numerical methods for differential equations (as covered in the course "Numerical Methods for Partial Differential Equations").

**Competencies**
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Personal Competencies: Critical Thinking fostered

**Core Courses (continued)**

*Only one of the two course units may be recognised for credits as a core course. However, the other course unit may be recognised for a different category.*

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
263-5210-00L | Probabilistic Artificial Intelligence | | | | |
252-0535-00L | Advanced Machine Learning | | | | |

For the category assignment take contact with the Study Administration [www.math.ethz.ch/studiensekretariat].
Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Fields of Specialization

Theoretical Astrophysics (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

Abstract
This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Content
This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

Literature
Course Materials:
1. The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
2. The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
3. Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
4. Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
5. Galactic Dynamics, James Binney and Scott Tremaine

Prerequisites / notice
This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

Prerequisites:
Introduction to Astrophysics
Mathematical Methods for the Physicist
Quantum Mechanics
(All preferred but not obligatory)

Prior Knowledge:
Mechanics
Quantum Mechanics and atomic physics
Thermodynamics
Fluid Dynamics
Electrodynamics

Computational Astrophysics (University of Zurich)

Abstract
This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Content
This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

Literature
Course Materials:
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2. The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
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Quantum Mechanics
(All preferred but not obligatory)

Prior Knowledge:
Mechanics
Quantum Mechanics and atomic physics
Thermodynamics
Fluid Dynamics
Electrodynamics
Content

1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Potential vorticity, Rossby waves, baroclinic instability
7. Conservation equations in a turbulent flow
8. Spectral characteristics
9. Scaling and similarity theory
10. Closure problem and closure assumptions
11. PBL structure and stability
12. Independently judge the applicability of learned concepts and tools to real-world situations.
13. Apply these concepts to answer comprehension questions and solve simple problems related to the structure and dynamics of the PBL.
14. Name the basic approaches needed to describe planetary boundary layer flows and associated turbulent exchange processes.
15. Apply these concepts to answer comprehension questions and solve simple problems related to the structure and dynamics of the PBL.
16. Identify the fundamental concepts of atmospheric boundary layer theory and apply them to real-world situations.
17. The Planetary Boundary Layer (PBL) constitutes the lower part of the atmosphere, which is characterized by turbulent mixing and ensures the exchange of energy, mass and momentum between the Earth’s surface and the atmosphere.
18. To explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.
19. The course provides the theoretical background for understanding the structure and dynamics of the PBL.
20. Idealized concepts are reviewed and contrasted to real-world applications.
21. Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial.

Literature

Galactic Dynamics (Binney & Tremaine, Princeton University Press),
Computer Simulation using Particles (Hockney & Eastwood CRC press),
Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

Prerequisites / notice

Students are able to:
- to explain the physical structure and chemical composition of the atmosphere
- to quantitatively describe and understand the fundamental physical and chemical process in the atmosphere
- to explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.

In the course "Atmosphere", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined.

Objective

Students are able to:
- to explain the physical structure and chemical composition of the atmosphere
- to quantitatively describe and understand the fundamental physical and chemical process in the atmosphere
- to explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.

In the course "Atmosphere", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined.

Content

Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Objective

Students are able to:
- to explain the physical structure and chemical composition of the atmosphere
- to quantitatively describe and understand the fundamental physical and chemical process in the atmosphere
- to explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.

In the course "Atmosphere", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined.

Literature


Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking

651-4053-05L Boundary Layer Meteorology
W 4 credits 3G M. Rotach, P. Calanca
Abstract

The Planetary Boundary Layer (PBL) constitutes the lower part of the atmosphere, which is characterized by turbulent mixing and ensures the exchange of energy, mass and momentum between the Earth’s surface and the atmosphere. The course provides the theoretical background for understanding the structure and dynamics of the PBL.

Objective

Students are able to:
- Name the basic approaches needed to describe planetary boundary layer flows and associated turbulent exchange processes.
- Apply these concepts to answer comprehension questions and solve simple problems related to the structure and dynamics of the PBL.
- Independently judge the applicability of learned concepts and tools to real-world situations.

Content

- Introduction
- PBL structure and stability
- Turbulence and turbulent transport
- Scaling and similarity theory
- Spectral characteristics
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Rough surfaces and the roughness sublayer
- Complex terrain

Lecture notes

available (i.e. in English)

Literature


Prerequisites / notice

Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial.

Method-specific Competencies
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking

Self-awareness and Self-reflection

701-1221-00L Dynamics of Large-Scale Atmospheric Flow
W 4 credits 2V+1U H. Wernli, J. Ribolli
Abstract

This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

Objective

Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.
Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Dynamics of large-scale atmospheric flow

- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Seminar cannot be taken. Please contact the lecturers (hanna.joos@env.ethz.ch) on time if you plan to take this seminar.

In this seminar it is mandatory to write a proposal about an upcoming MSc thesis or semester project. If no such project is planned, this proposal and evaluation of each other's work. Furthermore, an introduction to presentation skills is provided.

The process of writing a scientific proposal is introduced and the essential elements, including the peer review process, are outlined and class exercises train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work. An introduction to presentation skills is provided.

In this seminar, the process of writing a scientific proposal is introduced. The essential elements of a proposal, including the peer review process, are outlined and class exercises train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work. Furthermore, an introduction to presentation skills is provided.

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS
### Objective

The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. Examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.

### Content

1. Introductory lecture: basics of quantum mechanics and quantum chemistry
2. Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3. Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4. Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5. Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6. Relativistic effects in chemistry and the emergence of spin
7. Spin in density functional theory
8. New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group

### Lecture notes

A set of detailed lecture notes will be provided, which will cover the whole course.

### Literature

2. F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997 [english version available: F. Schwabl, Advanced Quantum Mechanics]

Note also the standard textbooks:

A) A. Szabo, N.S. Ostlund. Verlag, Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

### Prerequisites / notice

Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
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<td>Decision-making</td>
<td>fostered</td>
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<td>Problem-solving</td>
<td>fostered</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>fostered</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
</tr>
</tbody>
</table>

### 402-0205-00L Quantum Mechanics I

**W** 8 credits 3V+2U M. Kristic Marinkovic

*Physics BSc students with programme regulations 2016 need to register for* 402-0205-10L Quantummechanik I

**Abstract**


Applications: simple potentials in wave mechanics, scattering and resonance, harmonic oscillator, hydrogen atom, and perturbation theory.

**Objective**

Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

**Content**

The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.

**Lecture notes**

Auf Moodle

**Literature**

G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics

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### Seminar in Chemistry for CSE

**W 4 credits 2S** P. H. Hünenberger, M. Reiher

**Abstract**

The student will carry out a literature study on a topic of his or her liking (suggested by or in agreement with the supervisor) in the area of computer simulation in chemistry (Prof. Hünenberger) or of quantum chemistry (Prof. Reiher), the results of which are to be presented both orally and in written form.

For more information: [http://www.csms.ethz.ch/education/CSE_seminar.html](http://www.csms.ethz.ch/education/CSE_seminar.html)

### Fluid Dynamics

**One of the course units**

151-0103-00L Fluid Dynamics II  
151-0109-00L Turbulent Flows

**Students able to follow courses in German are advised to choose 151-0103-00L Fluid Dynamics II.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0109-00L</td>
<td>Turbulent Flows</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>P. Jenny</td>
</tr>
</tbody>
</table>

**Abstract**

Laminar and turbulent flows, instability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scalings, Homogeneous isotropic turbulence, correlations, Fourier representation, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows

**Objective**

Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling

**Content**

- Properties of laminar, transitional and turbulent flows.  
- Origin and control of turbulence, Instability and transition.  
- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.  
- Scalings, homogeneous isotropic turbulence, energy spectrum.  
- Turbulent free shear flows. Jet, wake, mixing layer.  
- Wall-bounded turbulent flows.  
- Turbulent flow computation and modeling.

**Lecture notes**

Lecture notes are available

**Literature**


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0532-00L</td>
<td>Nonlinear Dynamics and Chaos I</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>G. Haller</td>
</tr>
</tbody>
</table>

**Abstract**

Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

**Objective**

This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

**Content**

1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.

2. Near equilibrium dynamics: Linear and Lyapunov stability

3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations

4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.

5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

**Lecture notes**

The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

**Prerequisites / notice**

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>151-0213-00L</td>
<td>Fluid Dynamics with the Lattice Boltzmann Method</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>I. Karlin</td>
</tr>
</tbody>
</table>

The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.
Objective

Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.

Content

The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   - Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   - Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   - Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   - Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   - Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow:
   - Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   - Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   - Relativistic fluid dynamics; flows with phase transitions.

Lecture notes

Lecture notes on the theoretical parts of the course will be made available.

Selected original and review papers are provided for some of the lectures on advanced topics.

Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice

The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

Stochastic Methods for Engineers and Natural Scientists

W 4 credits 4G

D. W. Meyer-Massetti

Abstract

The course provides an introduction into stochastic methods that are applicable for the description, treatment, and modeling of systems that are subject to uncertainties or that respond to parameter changes in a chaotic manner. Corresponding systems may arise in fluid dynamics, structural mechanics, biology, electrical engineering as well as other areas.

Objective

By the end of the course you will be familiar with a range of mathematical/statistical tools that enable a quantitative treatment of problems that involve uncertainties.

Content

- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation
- Kalman filters (classical and ensemble-based)
- Statistical tests for means and goodness-of-fit

Lecture notes

Detailed lecture notes will be provided.

Literature

Some textbooks related to the material covered in the course:
### Systems and Control

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
</tbody>
</table>

**Abstract**

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Objective**

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Content**

- Process automation, concept of control. Modelling of dynamical systems - examples, state space description, linearisation, analytical-numerical solution, Laplace transform, system response for first and second order systems - effect of additional poles and zeros.

**Literature**


**Prerequisites / notice**

Prerequisites: Signal and Systems Theory II. MATLAB is used for system analysis and simulation.

| 227-0225-00L | Linear System Theory                 | W    | 6    | 5G     | J. Lygeros, A. Tsiamis |

**Abstract**

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

**Objective**

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

**Content**

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Lecture notes**

Available on the course Moodle platform.
Prerequisites / notice | Competencies | Content |
---|---|---|
Sufficient mathematical maturity, in particular in linear algebra, analysis. | Subject-specific Competencies | The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can |
| | Concepts and Theories | assessed |
| | Techniques and Technologies | assessed |
| Method-specific Competencies | Analytical Competencies | fostered |
| | Problem-solving | assessed |
| Personal Competencies | Creative Thinking | fostered |
| | Critical Thinking | fostered |
| | Integrity and Work Ethics | fostered |

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit</th>
<th>Type</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0532-00L</td>
<td>Nonlinear Dynamics and Chaos I</td>
<td>4</td>
<td>W</td>
<td>G. Haller</td>
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<tr>
<td></td>
<td>Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.</td>
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<td>This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.</td>
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<td></td>
<td>(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.</td>
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<td>(2) Near equilibrium dynamics: Linear and Lyapunov stability</td>
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<td>(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations</td>
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<td>(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.</td>
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<td>(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance</td>
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<td></td>
<td>Lecture notes</td>
<td>The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.</td>
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<td></td>
<td>Prerequisites / notice</td>
<td>- Prerequisites: Analysis, linear algebra and a basic course in differential equations.</td>
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<tr>
<td>151-0575-01L</td>
<td>Signals and Systems</td>
<td>4</td>
<td>W</td>
<td>A. Carron</td>
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<tr>
<td></td>
<td>Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.</td>
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<td></td>
<td>Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercises.</td>
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<td></td>
<td>Lecture notes</td>
<td>Lecture notes available on course website.</td>
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<td></td>
<td>Prerequisites / notice</td>
<td>Control Systems I is helpful but not required.</td>
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<tr>
<td>151-0563-01L</td>
<td>Dynamic Programming and Optimal Control</td>
<td>4</td>
<td>W</td>
<td>R. D'Andrea</td>
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<td></td>
<td>Introduction to Dynamic Programming and Optimal Control.</td>
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<td></td>
<td>Covers the fundamental concepts of Dynamic Programming &amp; Optimal Control.</td>
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<td></td>
<td>Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.</td>
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<td></td>
<td>Lecture notes</td>
<td>Lecture notes available on course website.</td>
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<td></td>
<td>Prerequisites / notice</td>
<td>Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.</td>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>10</td>
<td>W</td>
<td>C. Cotrini Jimenez</td>
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<td></td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.</td>
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<td>The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
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<td></td>
<td>Topics covered in the lecture include:</td>
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<td></td>
<td>Fundamentals:</td>
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<td></td>
<td>What is data?</td>
<td>Bayesian Learning</td>
<td>Computational learning theory</td>
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<td>Supervised learning:</td>
<td>Ensembles: Bagging and Boosting</td>
<td>Max Margin methods</td>
<td>Neural networks</td>
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<td>Unsupervised learning:</td>
<td>Dimensionality reduction techniques</td>
<td>Clustering</td>
<td>Mixture Models</td>
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<td></td>
<td>Lecture notes</td>
<td>No lecture notes, but slides will be made available on the course webpage.</td>
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</table>
Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

### Prerequisites
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### Literature

### 151-0371-00L Advanced Model Predictive Control

**Number of participants limited to 60.**

**Abstract**
Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

**Objective**
Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

**Content**
Topics include:
- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of regression methods
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

**Lecture notes**
Lecture notes will be provided.

**Prerequisites**
Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control in Spring Semester) strongly recommended.

Background in linear algebra and stochastic systems recommended.

### 401-5850-00L Seminar in Systems and Control for CSE

**Abstract**
Guided self study on a topic related to systems and control

**Competencies**
Subject-specific Competencies: Concepts and Theories fostered
Techniques and Technologies fostered

### Robotics

**Only one of the two course units**
263-5902-00L Computer Vision resp. 227-0447-00L Image Analysis and Computer Vision may be recognised for credits for the overall (CSE Bachelor and Master) study programmes.

**Only one of the two course units**
263-5210-00L Probabilistic Artificial Intelligence resp. 252-0535-00L Advanced Machine Learning may be recognised for credits in the field of specialisation 'Robotics' for the overall (CSE Bachelor and Master) study programmes. However, the other course unit may be recognised for a different category.

### Number Title Type ECTS Hours Lecturers

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6</td>
<td>3+1</td>
<td>E. Konukoglu, E. Erdil, F. Yu</td>
</tr>
<tr>
<td></td>
<td>Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.</td>
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<td>This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.</td>
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<tr>
<td></td>
<td>Lecture notes: Course material Script, computer demonstrations, exercises and problem solutions</td>
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<td>Prerequisites: Prerequisites:</td>
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| 252-0535-00L  | Advanced Machine Learning           | W    | 10   | 3+4   | C. Cotrini Jimenez |
|               | Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects. |      |      |       |                    |
|               | Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data. |      |      |       |                    |
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

No lecture notes, but slides will be made available on the course webpage.


The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### Courses

**252-3005-00L Natural Language Processing**

**Abstract**
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Objective**
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

**Content**
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Literature**
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

**263-3210-00L Deep Learning**

**Abstract**
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

**Prerequisites / notice**
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  - Advanced Machine Learning [link to website]
  - Computational Intelligence Lab [link to website]
  - Introduction to Machine Learning [link to website]
  - Statistical Learning Theory [link to website]
  - Computational Statistics [link to website]
  - Probabilistic Artificial Intelligence [link to website]

**151-0563-01L Dynamic Programming and Optimal Control**

**Abstract**
Introduction to Dynamic Programming and Optimal Control.
The students are familiar with the challenges of the fascinating and interdisciplinary field of Robotics and Mechatronics. They are familiar with the advanced topics of robotics and mechatronics research. The study plan is designed to provide an overview of how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

Objective
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Content
The course consists of three parts: First, we will refresh and deepen the student’s knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

Prerequisites / notice
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

401-5860-00L Seminar in Robotics for CSE

Abstract
This course provides an opportunity to familiarize yourself with the advanced topics of robotics and mechatronics research. The study plan has to be discussed with the lecturer based on your specific interests and/or the relevant seminar series such as the IRIS's Robotics Seminars and BiRiONZ lectures, for example.

Objective
The students are familiar with the challenges of the fascinating and interdisciplinary field of Robotics and Mechatronics. They are introduced in the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

Content
This 4 ECTS course requires each student to discuss a study plan with the lecturer and select minimum 10 relevant scientific publications to read through, or attend 5-10 lectures of the public robotics oriented seminars (e.g. Public robotics seminars such as the IRIS's Robotics Seminars http://www.iris.ethz.ch/iris/series/, and BiRiONZ lectures http://www.birl.ethz.ch/bironz/index are good examples). At the end of semester, the results should be presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.

Robotics (continued)

Only one of the two course units
263-5902-00L Computer Vision resp. 227-0447-00L Image Analysis and Computer Vision
may be recognised for credits for the overall (CSE Bachelor and Master) study programmes.

Only one of the two course units
263-5210-00L Probabilistic Artificial Intelligence resp. 252-0535-00L Advanced Machine Learning
may be recognised for credits in the field of specialisation 'Robotics' for the overall (CSE Bachelor and Master) study programmes. However, the other course unit may be recognised for a different category.

For the category assignment take contact with the Study Administration (www.math.ethz.ch/studiensekretariat).

Number Title Type ECTS Hours Lecturers

263-5902-00L Computer Vision

Abstract
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content
Camera models and calibration, invariant features, Multi-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

263-5210-00L Probabilistic Artificial Intelligence

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2214 of 2667
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and supercomputers. Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

For the field of specialization 'Physics' basic knowledge in quantum mechanics is required.
The course covers the key concepts and formalism of quantum information processing. Topics include quantum algorithms, quantum error correction, quantum cryptography, and quantum metrology, with an emphasis on the power of quantum information processing beyond that of classical information processing. The formalism of quantum states, measurements, and channels is developed in detail.

By the end of the course students are able to explain the basic mathematical formalism of quantum mechanics and apply it to quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

The topics covered in the course will include quantum circuits, gate decomposition and universal sets of gates, efficiency of quantum circuits, quantum algorithms (Shor, Grover, Deutsch-Josza,...), stabilizer-based quantum error correction, fault-tolerant designs, the BB84 quantum key distribution protocol, and simple methods of quantum metrology.

Prerequisites / notice
A good understanding of finite dimensional linear algebra is recommended.

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Problem-solving

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

The course offers 6 credits and requires 2V+1U

This is the first of two courses, introducing particle accelerators from a theoretical point of view and covers state-of-the-art modelling techniques.

You obtain a theoretical understanding of the building blocks of particle accelerators. Modern numerical analysis tools allows you to model state-of-the-art particle accelerators. We will develop a Julia simulation tool (JuliAccel.jl) that reflects the theory from the lecture.

Here is the rough plan of the topics, however the actual pace may vary relative to this plan.

- Recap of Relativistic Classical Mechanics and Electrodynamics
- Building Blocks of Particle Accelerators
- Lie Algebraic Structure of Classical Mechanics and Application to Particle Accelerators
- Symplectic Maps & Analysis of Maps
- Symplectic Particle Tracking
- Collective Effects
- Linear & Circular Accelerators

This lecture is also suited for PhD. students

**Subject-specific Competencies**
- Concepts and Theories
  - assessed

**Method-specific Competencies**
- Media and Digital Technologies
  - assessed

**Social Competencies**
- Communication
  - assessed

**Personal Competencies**
- Critical Thinking
  - assessed

The course offers 4 credits and requires 2S

First introduction to main modelling ideas and mathematical tools from mathematical finance

This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

See information on course homepage

401-3913-01L Mathematical Foundations for Finance

**Number** 401-3913-01L **Title** Mathematical Foundations for Finance **Type** W **ECTS** 4 **Hours** 3V+2U **Lecturers** D. Possamaï

First introduction to main modelling ideas and mathematical tools from mathematical finance

This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Topics to be covered include

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

See information on course homepage
Prerequisites / notice

Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitstheorie".)

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
  - Techniques and Technologies: fostered
Method-specific Competencies
- Analytical Competencies: assessed
  - Decision-making: fostered
  - Problem-solving: assessed
Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

401-4657-00L Numerical Solution of Stochastic Ordinary Differential Equations

Abstract
This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering.

The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective
The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content
- Brownian motion and Lévy processes
- Stochastic integration and stochastic calculus
- Stochastic ordinary differential equations (SDEs)
- Numerical approximations of SDEs
- Stochastic simulation and Monte Carlo methods
- Applications to computational finance: Option valuation

Lecture notes
There will be English, typed lecture notes for registered participants in the course.

Literature

Prerequisites /
notice

Mandatory:
- Probability and measure theory,
- basic numerical analysis and
- basics of MATLAB/Python programming.

a) mandatory courses:
  - Measure - and Probability Theory I

as covered in courses:
  - ETH 401-2283-00L Analysis III (Measure Theory)
  - UZH Kursmodul 10498 Hauptvorlesung: Mass- und Integrationstheorie

b) recommended courses:
  - Stochastic Processes I
### Electromagnetics

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<th>Number</th>
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<th>ECTS</th>
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<tr>
<td>227-0110-00L</td>
<td>Electromagnetic Waves: Materials, Effects, and Antennas</td>
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<td><strong>Abstract</strong></td>
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<td>This course provides profound knowledge about electromagnetic waves.</td>
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<td>Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.</td>
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<td>• Radio frequency and optical antennas</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
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<td>J. Smajic</td>
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Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to iteratively improve the models till satisfactory accurate results are obtained.

Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

227-0301-00L Optical Communication Fundamentals
W 6 credits 2V+1U+1P J. Leuthold

Abstract
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

Objective
An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

Content

* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.


* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimates.

* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection technques, Error correction coding.

* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

* Chapter 7: Optical Amplifiers : Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes
Lecture notes are handed out.

Literature
Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

Prerequisites / notice

401-4785-00L Mathematical and Computational Methods in Photonics
W 7 credits 4G H. Ammari

Abstract
The aim of this course is to review new and fundamental mathematical tools, computational approaches, and inversion and optimal design methods used to address challenging problems in nanophotonics. The emphasis will be on analyzing plasmon resonant nanoparticles, super-focusing & super-resolution of electromagnetic waves, photonic crystals, electromagnetic cloaking, metamaterials, and metasurfaces and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena.

Objective
The field of photonics encompasses the fundamental science of light propagation and interactions in complex structures, and its technological applications. The recent advances in nanoscience present great challenges for the applied and computational mathematics community. In nanophotonics, the aim is to control, manipulate, reshape, guide, and focus electromagnetic waves at nanometer length scales, beyond the resolution limit. In particular, one wants to break the resolution limit by reducing the focal spot and confine light to length scales that are significantly smaller than half the wavelength.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare. Light-based technologies can be used effectively for the very early detection of diseases, with non-invasive imaging techniques or point-of-care applications. They are also instrumental in the analysis of processes at the molecular level, giving a greater understanding of the origin of diseases, and hence allowing prevention along with new treatments. Photonic technologies also play a major role in addressing the needs of our ageing society; from pace-makers to synthetic bones, and from endoscopes to the micro-cameras used in vivo processes. Furthermore, photonics are also used in advanced lighting technology, and in improving energy efficiency and quality. By using photonic media to control waves across a wide band of wavelengths, we have an unprecedented ability to fabricate new materials with specific microstructures.

The main objective in this course is to report on the use of sophisticated mathematics in diffractive optics, plasmonics, super-resolution, photonic crystals, and metamaterials for electromagnetic invisibility and cloaking. The book merges highly nontrivial multi-mathematics in order to make a breakthrough in the field of mathematical modelling, imaging, and optimal design of optical nanodevices and nanostructures capable of light enhancement, and of the focusing and guiding of light at a subwavelength scale. We demonstrate the power of layer potential techniques in solving challenging problems in photonics, when they are combined with asymptotic analysis and the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions.

In this course we shall consider both analytical and computational matters in photonics. The issues we consider lead to the investigation of fundamental problems in various branches of mathematics. These include asymptotic analysis, spectral analysis, mathematical imaging, optimal design, stochastic modelling, and analysis of wave propagation phenomena. On the other hand, deriving mathematical foundations, and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena.

An emphasis is put on mathematically analyzing plasmon resonant nanoparticles, diffractive optics, photonic crystals, super-resolution, and metamaterials.

401-5870-00L Seminar in Electromagnetics for CSE
W 4 credits 2S J. Smajic

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2219 of 2667
Various topics of electromagnetics, including electromagnetic theory, computational electromagnetics, electromagnetic wave propagation, applications from statics to optics. Traditional problems such as antennas, electromagnetic scattering, waveguides, resonators, etc. as well as modern topics such as photonic crystals, metamaterials, plasmonics, etc. are considered.

Knowledge of the fundamentals of electromagnetic theory, development and application of numerical methods for solving Maxwell equations, analysis and optimal design of electromagnetic structures

Abstract

In this course, students learn crucial partial differential equations (conservation laws) that are applicable to any continuum including the Earth's mantle, core, atmosphere and ocean. The course will provide step-by-step introduction into the mathematical structure, physical meaning and analytical solutions of the equations. The course has a particular focus on solid Earth applications.

The goal of this course is to learn and understand few principal partial differential equations (conservation laws) that are applicable for analysing and modelling of any continuum including the Earth's mantle, core, atmosphere and ocean. By the end of the course, students should be able to write, explain and analyse the equations and apply them for simple analytical cases. Numerical solving of these equations will be discussed in the Numerical Modelling I and II course running in parallel.

A provisional week-by-week schedule (subject to change) is as follows:

Weeks 1,2: The continuity equation
Exercise: Computing the divergence of velocity field.

Weeks 3,4: Density and gravity
Exercises: Computing density, thermal expansion and compressibility from an equation of state. Derivation of gravitational acceleration and its divergence from gravitational potential.

Weeks 5,6: Stress and strain
Exercises: Analysing strain rate tensor for solid body rotation. Computing stress invariants

Weeks 7,8: The momentum equation

Week 9: Viscous rheology of rocks
Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth's interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws.
Exercise: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

Weeks 10: The heat conservation equation

Week 11,12: Elasticity and plasticity


GRADING will be based on homeworks (1/3) and oral exam (2/3).

Script and Exam questions are available by request tgerya@ethz.ch


Concepts and Theories assessed
Analytical Competencies assessed
Problem-solving assessed

In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasise a hands-on learning approach rather than extensive theory.
Objective

The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.

Content

A provisional week-by-week schedule (subject to change) is as follows:

Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity with stream function/vorticity formulation.


Weeks 5: Conservative finite differences for the momentum equation. “Free slip” and “no slip” boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advective in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


Week 14: Final project description for slab breakup modeling.

GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Literature


Competencies

Subject-specific Competencies

Concepts and Theories assessed

Analytical Competencies assessed

Decision-making fostered

Media and Digital Technologies assessed

Problem-solving assessed

Personal Competencies

Creative Thinking fostered

Geophysics: Subject 3

Offered in the spring semester

Geophysics: Subject 4

Offered in the spring semester

Geophysics: Subject 5

Objectives

Understand the strengths and weaknesses of various active and passive tomographic methods to image the Earth’s interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body-wave and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.

Reference Literature

### Geophysics: Subject 6

**Offered in the spring semester**

### Geophysics: Subject 7

**Offered in the spring semester**

### Geophysics: Subject 8

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<th>Number</th>
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<td>651-4273-00L</td>
<td>Numerical Modelling in Fortran</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Tackley</td>
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<td><strong>Abstract</strong></td>
<td>This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.</td>
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<td><strong>Objective</strong></td>
<td>Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.</td>
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<td><strong>Lecture notes</strong></td>
<td>See <a href="http://jupiter.ethz.ch/~pjt/FORTRAN/FortranClass.html">http://jupiter.ethz.ch/~pjt/FORTRAN/FortranClass.html</a></td>
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### Geophysics: Seminar

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<td>Seminar in Geophysics for CSE</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>T. Gerya, P. Tackley</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The seminar in geophysics for CSE is a work on a small research project for 4 credit points. The project can be supervised and graded by any member of the Institute of Geophysics with doctoral degree</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Students will learn modern quantitative geophysical research by conducting a small original project on a relevant subject.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Students should find a project of interest by contacting potential supervisors from the Institute of Geophysics and agree on the content and timing of the project. At the end of the project, a written report of free format should be submitted by the student, which is then graded by the supervisor.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>No script</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Relevant literature should be provided by the project supervisor.</td>
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</table>

### Biology

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modelling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.</td>
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</table>
Content

Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes
http://www.csb.ethz.ch/education/lectures.html

Literature

636-0017-00L
Computational Biology

W 6 credits
3G+2A
T. Vaughan, C. Magnus, T. Stadler

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
* epidemiology
* pathogen evolution
* macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylo dynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.

Literature
Lecture notes are not based on any of the textbooks below, but they are excellent choices as accompanying material:
* Yang, Z. 2006. Computational Molecular Evolution.
* Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

636-0706-00L
Spatio-Temporal Modelling in Biology

W 4 credits
3G
D. Iber

Abstract
This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on mechanisms and concepts, but mathematical and numerical techniques are introduced as required. Biological examples discussed in the course provide an introduction to key concepts in developmental biology.

Objective
Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

Content
1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

Lecture notes
All lecture material will be made available online via Moodle.
The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

227-0421-00L Learning in Deep Artificial and Biological Neuronal Networks

Abstract
Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective
The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. Thus, the course introduces training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today’s neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to ‘error backpropagation’ in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Content
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al., 2015, Silver et al., 2018).

ANNs are still not performing on par when it comes to recognizing actions in movies and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the use of local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes
The lecture slides will be provided as a PDF after each lecture.

Prerequisites / notice
This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:
1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

227-1037-00L Introduction to Neuroinformatics

Abstract
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties, neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neuronal architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

551-1299-00L Bioinformatics

Abstract
Students will study bioinformatic concepts in the areas of metagenomics, genomics, transcriptomics, proteomics, biological networks and biostatistics. Through integrated lectures, practical hands-on exercises and project work, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Course participants have already acquired basic programming skills in UNIX, Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

In the 'electives' subcategory, at least two course units must be successfully completed.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
</table>

Abstract
This course aims to cover state-of-the-art methods in modern parallel computing on Graphics Processing Unit (GPU), supercomputing and code development with applications to natural sciences and engineering.

Objective
When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

Content
Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn how to solve diffusion, wave propagation and advection processes;
- Implement efficient iterative algorithms;
- Get started with software development tools: git, version control.

Part 2 - Developing your own parallel algorithms on GPUs
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Understand the practical challenges of parallel computing: GPUs, multi-core CPUs;
- Learn about main simulation performance limiters;
- Implement software development tooling: unit tests, continuous integration (CI).

Part 3 - Multi-GPU computing projects
- Understand the practical challenges of distributed parallel computing on multi-GPUs;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPU); Automatic to software tooling using remote runners.

Final projects
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites / notice
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Year</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0317-00L</td>
<td>Visualization, Simulation and Interaction - Virtual Reality II</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Kunz</td>
</tr>
<tr>
<td>Objective</td>
<td>This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.</td>
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<tr>
<td>Content</td>
<td>Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems. The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.</td>
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<tr>
<td>Lecture notes</td>
<td>The handout is available in German and English.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>&quot;Visualization, Simulation and Interaction - Virtual Reality II&quot; is recommended, but not mandatory,</td>
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<tr>
<td>Didactical concept:</td>
<td>The course consists of lectures and exercises.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies: Concepts and Theories; Techniques and Technologies</td>
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<td></td>
<td>Method-specific Competencies: Analytical Competencies; Media and Digital Technologies</td>
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<td>Social Competencies: Communication</td>
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<td>Personal Competencies: Critical Thinking</td>
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<tr>
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<th>Year</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>151-0833-00L</td>
<td>Applied Finite Element Analysis</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>B. Berisha, D. Mohr</td>
</tr>
<tr>
<td>Objective</td>
<td>Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.</td>
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<tr>
<td>Content</td>
<td>The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:</td>
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<td>- Crash</td>
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<td>- Collapse of structures</td>
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<td></td>
<td>- Material behavior (metals and rubber)</td>
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<td>- General forming processes</td>
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<td>Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture slides</td>
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<thead>
<tr>
<th>Course Code</th>
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<th>Year</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>151-0529-00L</td>
<td>Nonlinear FEA</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>L. De Lorenzis</td>
</tr>
<tr>
<td>Objective</td>
<td>The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).</td>
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<tr>
<td>Content</td>
<td>To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes will be provided. However, students are encouraged to take their own notes.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.</td>
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<th>Year</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>W</td>
<td>9</td>
<td>2V+2U+4A</td>
<td>T. Hoefler</td>
</tr>
<tr>
<td>Objective</td>
<td>Advanced topics in parallel and high-performance computing. Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become familiar with important technical concepts and with concurrency folklore.</td>
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Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2226 of 2667
### Content

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

### Prerequisites / notice

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

<table>
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<tr>
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<th>Credits</th>
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<tbody>
<tr>
<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>5</td>
<td>Z. Bauer, C. Holz, M. Pollefeys</td>
</tr>
</tbody>
</table>

**Abstract**

The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

**Objective**

After attending this course, students will:

1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

**Content**

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:

- Introduction to Mixed Reality / Augmented Reality / Virtual Reality
- Introduction to 3D Computer Graphics, 3D Computer Vision.
- This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art.
- The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application.
- The project topics are flexible and can reach from proof-of-concept vision / graphics / HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

**Prerequisites / notice**

- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Coordinator</th>
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</thead>
<tbody>
<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems</td>
<td>6</td>
<td>L. Josipovic, L. Vanbeever, R. Wattenhofer</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.

**Objective**

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by exploring the limits of what is computable and what is not. In doing so, we will consider three distinct models of computation which are often used to model discrete event systems: finite automata, push-down automata and Turing machines (ranked in terms of expressiveness power). In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply continuous time markov chains and queueing theory for an understanding of the typical behavior of a system. Then we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queueing. In the last part of the course we introduce methods that allow to formally verify certain properties of Finite Automata and Petri Nets. These are some typical analysis questions we will look at: Do two given systems behave the same? Does a given system behave as intended? Does the system eventually enter a dangerous state?

**Content**

1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets

**Lecture notes**

Available at https://disco.ethz.ch/courses/des/
Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog.
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes
Textbook and all further documents in English.

Literature
Understanding the specific requirements and problems that arise in embedded system applications.

Embedded Systems

An embedded system is a combination of hardware and software, either fixed in function or programmable, that is designed for a specific application scenario or for a specific task within a larger system. They are part of industrial machines such as agricultural and manufacturing equipment, automotive systems, medical equipment, household appliances, sensor networks, and the Internet of Things.

Using formal models and methods for designing and optimizing embedded systems.

Gaining experience with practical applications of the C programming language, embedded real-time operating systems, and debug functionalities of the associated design environment to design, implement, and verify embedded firmware.

Through project-based activities, students will gain substantial experience in applying the C programming language in the context of embedded systems. Projects will involve developing and implementing firmware, utilizing embedded real-time operating systems, and exploring the debugging functionalities within design environments. This hands-on approach aims to bridge the gap between theoretical knowledge and practical application, allowing students to experience the full lifecycle of embedded system development from design to implementation and verification.
This lecture focuses on the design of embedded systems using formal models and methods.

Besides the theoretical lecture, the course contains laboratory sessions where students transfer the learned theoretical aspects into praxis by programming a microcontroller and interfacing it with sensors and actuators. Students will be exposed to a commercial microcontroller, and the development board extend with a custom-designed embedded systems educational platform.

Specifically, the following topics will be covered in the course: hardware and software structures of embedded systems, low-level instruction set, memory architecture and memory map, peripherals, hardware-software interfaces, communication between components, firmware design methodologies, firmware design using the C programming language, embedded real-time operating systems, real-time scheduling, shared resources, low-power, and low-energy designs well as computational accelerators.

Lecture notes
Lecture material, publications, exercise sheets, and laboratory documentation will be available on the course's Moodle page.

Prerequisites / notice
Prerequisites: C programming, circuit theory, digital logic, binary number representations.
Recommended: basic knowledge of assembly programming and computer architecture.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Content
This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.

Abstract
This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.

Objective
The course aims at bridging the gap between mathematical modelers and clinical neuroscientists by teaching computational techniques in the context of clinical applications. The hope is that the acquisition of a joint language and tool-kit will enable more effective communication and joint translational research between fields that are usually worlds apart.

Content
This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/ for details.

Literature

Prerequisites:
Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Content
This course covers fundamental and advanced concepts of modern computer graphics. Students will learn the fundamentals of digital scene representations, advanced physically-based light transport algorithms for generating photo-realistic images from these scene representations, and inverse rendering methods for recovering digital scene representations from captured images.

Objective
At the end of the course, the students will be able to build a rendering system based on path-tracing algorithms. The students will learn the principles of physically-based rendering and computer graphics. In addition, the course is intended to stimulate the student's curiosity to explore the field of computer graphics in subsequent classes or on their own.

Content
We will begin with an introduction to light emission and radiometric quantities, followed by an exploration of geometry representations and texture mapping.
Next, we will mathematically formulate the physics of light transport and appearance modeling.
Subsequently, we will introduce relevant concepts from Monte Carlo integration and develop path-tracing algorithms to solve these equations by simulating light transport for direct and global illumination due to hard surfaces and participating media, such as fog, smoke, and translucent objects.
Moreover, we will present techniques for significantly improving path-tracing efficiency, including importance sampling, multiple importance sampling, stratified sampling, denoising, and acceleration data structures.
The course lectures will conclude with an overview of image-based capture and rendering methods. Topics covered will include geometry reconstruction, material acquisition, differentiable rendering, and image-based rendering.
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:

- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

The course considers classical low-dimensional models, with pointers towards today's highly complex models.

The programming assignments will be in C++. This will not be taught in the class.

**Literature**
Books:
- Fundamentals of Mathematical Statistics
- High-Dimensional Statistics
- Time Series Analysis

**Prerequisites / notice**
- Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, and the Visual Computing course are recommended.
- The programming assignments will be in C++. This will not be taught in the class.

**Competencies**

### Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

### Social Competencies
- Communication fostered
- Cooperation and Teamwork assessed
- Leadership and Responsibility fostered

### Personal Competencies
- Creative Thinking assessed
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-direction and Self-management fostered

**252-0546-00L** Physically-Based Simulation in Computer Graphics

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**Objective**
The lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

**Content**
The lecture covers topics such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

**Prerequisites / notice**
- Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

**Literature**
Books:
- Fundamentals of Mathematical Statistics
- High-Dimensional Statistics
- Time Series Analysis

**Prerequisites / notice**
- Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, and the Visual Computing course are recommended.
- The programming assignments will be in C++. This will not be taught in the class.

**Competencies**

### Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

### Personal Competencies
- Creative Thinking assessed
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-direction and Self-management fostered

**401-3621-00L** Fundamentals of Mathematical Statistics

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**Objective**
The lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

**Content**
The lecture covers topics such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

**Prerequisites / notice**
- Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

**Literature**
Books:
- Fundamentals of Mathematical Statistics
- High-Dimensional Statistics
- Time Series Analysis

**Prerequisites / notice**
- Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, and the Visual Computing course are recommended.
- The programming assignments will be in C++. This will not be taught in the class.

**Competencies**

### Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

### Personal Competencies
- Creative Thinking assessed
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-direction and Self-management fostered

**401-3627-00L** High-Dimensional Statistics

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**Objective**
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

**Content**
Knowledge of methods and basic theory for high-dimensional statistical inference.

Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling.


**Prerequisites / notice**
- Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

**401-4623-00L** Time Series Analysis

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**Objective**
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

**Content**
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:

- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis.
### Prerequisites / notice

401-3901-00L **Linear & Combinatorial Optimization**

**Basic knowledge in probability and statistics**

#### Objective

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

#### Content

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

#### Literature


#### Prerequisites / notice

Solid background in linear algebra.

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### 401-4944-20L **Mathematics of Data Science**

Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

#### Objective

Introduction to various mathematical aspects of Data Science.

#### Content

These topics lie in overlaps of Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Most lectures will feature Mathematical Open Problems. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

#### Lecture notes


#### Prerequisites / notice

The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

#### Competencies

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

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### 402-0448-02L **Quantum Information Processing II: Implementations**

This experimental part QIP II together with the theory part 402-0448-01L QIP I (both offered in the autumn semester) combine to the core course in experimental physics "Quantum Information Processing" (totally 10 ECTS credits). This applies to the Master's degree programme in

#### Prerequisites / notice

Solid background in linear algebra.

Throughout the past 20 years the realm of quantum physics has entered the domain of information technology in more and more prominent ways. Enormous progress in the physical sciences and in engineering and technology has allowed us to build novel types of information processors based on the concepts of quantum physics. In these processors information is stored in the quantum state of physical systems forming quantum bits (qubits). The interaction between qubits is controlled and the resulting states are read out on the level of single quanta in order to process information. Realizing such challenging tasks is believed to allow constructing an information processor much more powerful than a classical computer. This task is taken on by academic labs, startups and major industry. The aim of this class is to give a thorough introduction to physical implementations pursued in current research for realizing quantum information processors. The field of quantum information science is one of the fastest growing and most active domains of research in modern physics.

Introduction to experimental systems for quantum information processing (QIP).

- Quantum bits
- Coherent Control
- Measurement
- Decoherence
- QIP with Ions
- Superconducting Circuits
- Photons
- NMR
- Rydberg atoms
- NV-centers
- Quantum dots

Course material be made available at www.qudev.ethz.ch and on the Moodle platform for the course. More details to follow.

Quantum Computation and Quantum Information
Michael Nielsen and Isaac Chuang
Cambridge University Press

The class will be taught in English language.

Basic knowledge of concepts of quantum physics and quantum systems, e.g. from courses such as Physics III, Quantum Mechanics I and II or courses on topics such as atomic physics, solid state physics, quantum electronics are considered helpful.

More information on this class can be found on the web site www.qudev.ethz.ch

Neural Network Theory

W 4 credits 2V+1U  H. Bölcskei

Does not take place this semester.

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

Detailed lecture notes are available on the course web page https://www.mins.ee.ethz.ch/teaching/nt/nnt/

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

Neuromorphic Engineering I

W 6 credits 2V+3U T. Delbrück, G. Indiveri, S.-C. Liu, M. Payvand

Registration in this course unit requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Understanding of the characteristics of neuromorphic circuit elements.
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Prerequisites / notice

252-0209-00L Algorithms, Probability, and Computing  W  8 credits  4V+2U+1A  B. Gärtner, R. Kyng, A. Steger, D. Steurer

Abstract

Advanced design and analysis methods for algorithms and data structures: Random(ized) Search Trees, Point Location, Minimum Cut, Linear Programming, Randomized Algebraic Algorithms (matchings), Probabilistically Checkable Proofs (introduction).

Objective

Studying and understanding of fundamental advanced concepts in algorithms, data structures and complexity theory.

Literature


263-2400-00L Reliable and Trustworthy Artificial Intelligence  W  6 credits  2G+2V+1A  M. Vechev

Abstract

Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Objective

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

Content

The course is split into 4 parts:

Robustness of Machine Learning

- Adversarial attacks and defenses on deep learning models.
- Certified training of deep neural networks (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacks to the federated machine learning (across vision, natural language and tabular data).
- Differential privacy for defending machine learning.
- AI Regulations and checking model compliance.

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness (for both vision and tabular data).
- Enforcing group fairness (e.g., demographic parity, equalized odds).

Robustness, Privacy and Fairness of Foundation Models

- We discuss all previous topics, as well as programmability, in the context of latest foundation models (e.g., LLMs).


Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Personal Competencies

- Creative Thinking
- Critical Thinking

227-0627-00L Applied Computer Architecture  W  6 credits  4G  A. Gunzinger

Abstract

This lecture gives an overview of the requirements and the architecture of parallel computer systems, performance, reliability and costs. Understand the function, the design and the performance modeling of parallel computer systems.
The lecture "Applied Computer Architecture" gives technical and corporate insights in innovative Computer Systems/Architectures (CPU, GPU, FPGA, dedicated processors) and their real implementations and applications. Often the designs have to deal with technical limits.

Which computer architecture allows the control of the over 1000 magnets at the Swiss Light Source (SLS) at the PSI?
Which architecture is behind the alarm center of the Swiss Railway (SBB)?
Which computer architecture is hidden behind a professional digital audio mixing desk?
Which computer architectures are applied for driver assistance systems?
How could a fast trading system be set up for the stock exchange?
Can the weather forecast also be processed with GPUs?
How can data streams of about 30 TB/s, produced by a proton accelerator, be processed in real time?

see also Fields of Specialization

Case Studies

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<tr>
<td>401-3667-74L</td>
<td>Case Studies Seminar (Autumn Semester 2024)</td>
<td>W</td>
<td>3 credits</td>
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<td>V. C. Gradinaru, R. Hiptmair, R. Käppeli</td>
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Abstract
Invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list.

Objective
+ actual techniques for the presentation of scientific results in a scientific talk
+ awareness of actual questions in research and development in CSE related areas

Content
In the CSE Case Studies Seminar invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list (containing articles from, e.g., Nature, Science, Scientific American, etc.). If the underlying paper comprises more than 15 pages, two or three consecutive case studies presentations delivered by different students can be based on it. Consistency in layout, style, and contents of those presentations is expected.

Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

Prerequisites / notice
75% attendance and a short presentation on a published paper out of a list or on some own project are mandatory.

Students have to register their presentations online until the first Sundnday of the semester on https://rw.ethz.ch/the-programme/case-studies.html

The student talks will be grouped by subject, so we'll decide the actual dates of the individual talks.

Students that realize that they will not fulfill this criteria have to contact the teaching staff or de-register before the end of semester from the Seminar if they want to avoid a "Fail" in their documents. Later de-registrations will not be considered.

Semester Paper
There are several course units "Semester Paper" that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.
### Science in Perspective

Two credits are needed from the “Science in Perspective” programme with language courses excluded if three credits from language courses have already been recognised for the Bachelor's degree.

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- Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)
- Learn the basic standards of scientific works in mathematics.
- Types of mathematical works
- Publication standards in pure and applied mathematics
- Data handling
- Ethical issues
- Citation guidelines

**Prerequisites / notice**

Directive [https://www.ethz.ch/content/dam/ethz/...](https://www.ethz.ch/content/dam/ethz/...)

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### Master's Thesis

If you wish to have recognised 402-2000-00L Scientific Works in Physics instead of 401-2000-00L Scientific Works in Mathematics (as allowed for the CSE programme), take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having passed the performance assessment.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2000-00L</td>
<td>Scientific Works in Physics</td>
<td>W</td>
<td>0</td>
<td></td>
<td>D. Kienzler</td>
</tr>
</tbody>
</table>

- Target audience: Master students who cannot document to have received an adequate training in working scientifically.
- Optional MathBib training course

**Prerequisites / notice**

Directive [https://www.ethz.ch/content/dam/ethz/...](https://www.ethz.ch/content/dam/ethz/...)

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Abstract

Literature Review: ETH-Library, Journals in Physics, Google Scholar; Thesis Structure: The IMRAD Model; Document Processing: LaTeX and BibTeX, Mathematical Writing, AVETH Survival Guide; ETH Guidelines for Integrity; Authorship Guidelines; ETH Citation Etiquettes; Declaration of Originality.

Objective

Basic standards for scientific works in physics: How to write a Master Thesis. What to know about research integrity.

401-4990-01L Master's Thesis

Only students who fulfil the following criteria are permitted to commence the Master's thesis:

a. successful completion of the Bachelor's programme;

b. fulfilling of any additional requirements necessary to gain admission to the Master's programme;

c. successful completion of:

1) at least two course units in the category 'Core courses';

2) at least five course units, including a seminar, in the category 'Fields of specialisation'; and

3) the semester paper.

Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics or 402-2000-00L Scientific Works in Physics is required.

Approval via the form https://my.cse.ethz.ch/ is MANDATORY (caution: in myStudies all lecturers can be selected despite the fact that some of them are actually not authorised as supervisors).

Abstract

The master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective

Thesis work should prove the students' ability to independent, structured and scientific working.

Colloquia

Number | Title | Type | ECTS | Hours | Lecturers

| 401-5650-00L | Zurich Colloquium in Applied and Computational Mathematics | Research colloquium | E- | 0 credits | 1K | R. Alifari, H. Ammari, R. Hiptmair, S. Mishra, C. Schwab |

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

Number | Title | Type | ECTS | Hours | Lecturers

| 401-0363-AAL | Analysis III | Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit. | E- | 4 credits | 9R | A. Iozzi |

Abstract

Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective

Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

Content

Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates; Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform
Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student’s t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered

406-0603-AAL Stochastics (Probability and Statistics) E- 4 credits 9R M. Kalisch
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
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Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered

401-2673-AAL Numerical Methods for CSE E- 9 credits 19R not available
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
he course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.

Objective
* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently
Content
- Direct Methods for linear systems of equations
- Least Squares Techniques
- Data Interpolation and Fitting
- Filtering Algorithms
- Approximation of Functions
- Numerical Quadrature
- Iterative Methods for non-linear systems of equations

Lecture notes
Lecture materials (PDF documents and codes) will be made available to participants.

Literature


M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

Prerequisites / notice
Solid knowledge about fundamental concepts and techniques from linear algebra & calculus as taught in the first year of science and engineering curricula.

The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves.

401-0674-AAL Numerical Methods for Partial Differential Equations E- 10 credits 21R not available

Abstract
Derivation, properties, and implementation of fundamental numerical methods for a few key partial differential equations: convection-diffusion, heat equation, wave equation, conservation laws. Implementation in C++ based on a finite element library.

Objective
Main skills to be acquired in this course:
- Ability to implement fundamental numerical methods for the solution of partial differential equations efficiently.
- Ability to modify and adapt numerical algorithms guided by awareness of their mathematical foundations.
- Ability to select and assess numerical methods in light of the predictions of theory
- Ability to identify features of a PDE (= partial differential equation) based model that are relevant for the selection and performance of a numerical algorithm.
- Ability to understand research publications on theoretical and practical aspects of numerical methods for partial differential equations.
- Skills in the efficient implementation of finite element methods on unstructured meshes.

This course is neither a course on the mathematical foundations and numerical analysis of methods nor an course that merely teaches recipes and how to apply software packages.
1 Case Study: A Two-point Boundary Value Problem [optional]

1.1 Introduction
1.2 A model problem
1.3 Variational approach
1.4 Simplified model
1.5 Discretization
1.5.1 Galerkin discretization
1.5.2 Collocation [optional]
1.5.3 Finite differences
1.6 Convergence

2 Second-order Scalar Elliptic Boundary Value Problems
2.1 Equilibrium models
2.1.1 Taut membrane
2.1.2 Electrostatic fields
2.1.3 Quadratic minimization problems
2.2 Sobolev spaces
2.3 Variational formulations
2.4 Equilibrium models: Boundary value problems

3 Finite Element Methods (FEM)
3.1 Galerkin discretization
3.2 Case study: Triangular linear FEM in two dimensions
3.3 Building blocks of general FEM
3.4 Lagrangian FEM
3.4.1 Simplicial Lagrangian FEM
3.4.2 Tensor-product Lagrangian FEM
3.5 Implementation of FEM in C++
3.5.1 Mesh file format (Gmsh)
3.5.2 Mesh data structures (DUNE)
3.6 Assembly
3.7 Local computations and quadrature
3.8 Incorporation of essential boundary conditions
3.9 Parametric finite elements
3.9.1 Affine equivalence
3.9.2 Example: Quadrilateral Lagrangian finite elements
3.9.3 Transformation techniques
3.9.4 Boundary approximation
3.9.5 Linearization [optional]
4 Finite Differences (FD) and Finite Volume Methods (FV) [optional]
4.1 Finite differences
4.2 Finite volume methods (FVM)
5 Convergence and Accuracy
5.1 Galerkin error estimates
5.2 Empirical Convergence of FEM
5.3 Finite element error estimates
5.4 Elliptic regularity theory
5.5 Variational crimes
5.6 Duality techniques [optional]
5.7 Discrete maximum principle [optional]
6 2nd-Order Linear Evolution Problems
6.1 Parabolic initial-boundary value problems
6.1.1 Heat equation
6.1.2 Spatial variational formulation
6.1.3 Method of lines
6.1.4 Timestepping
6.1.5 Convergence
6.2 Wave equations [optional]
6.2.1 Vibrating membrane
6.2.2 Wave propagation
6.2.3 Method of lines
6.2.4 Timestepping
6.2.5 CFL-condition
7 Convection-Diffusion Problems [optional]
7.1 Heat conduction in a fluid
7.1.1 Modelling fluid flow
7.1.2 Heat convection and diffusion
7.1.3 Incompressible fluids
7.1.4 Transient heat conduction
7.2 Stationary convection-diffusion problems
7.2.1 Singular perturbation
7.2.2 Upwinding
7.3 Transient convection-diffusion BVP
7.3.1 Method of lines
7.3.2 Transport equation
7.3.3 Lagrangian split-step method
7.3.4 Semi-Lagrangian method
8 Numerical Methods for Conservation Laws
8.1 Conservation laws: Examples
8.2 Scalar conservation laws in 1D
8.3 Conservative finite volume discretization
8.3.1 Semi-discrete conservation form
8.3.2 Discrete conservation property
8.3.3 Numerical flux functions
8.3.4 Monge-Ampere schemes
8.4 Timestepping
8.4.1 Linear stability
8.4.2 CFL-condition
8.4.3 Convergence
8.5 Higher order conservative schemes [optional]
8.5.1 Slope limiting
8.5.2 MUSCL scheme
8.6. FV-schemes for systems of conservation laws [optional]

"optional" indicates that the corresponding topic might be skipped depending on the progress of the course.

Lecture notes
The lecture will be taught in flipped classroom format:
- Video tutorials for all thematic units will be published online.
- Solution of homework problems will partly be covered by video tutorials.
- Lecture documents and tablet notes accompanying the videos will be made available to the audience as PDF.

Literature
Chapters of the following books provide supplementary reading (detailed references in course material):


However, study of supplementary literature is not important for following the course.

Prerequisites / notice
Mastery of basic calculus and linear algebra is taken for granted.
Familiarity with fundamental numerical methods (solution methods for linear systems of equations, interpolation, approximation, numerical quadrature, numerical integration of ODEs) is essential.

Important: Coding skills and experience in C++ are essential.

Homework assignments involve substantial coding, partly based on a C++ finite element library. The written examination will be computer based and will comprise coding tasks.

### Computational Science and Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
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### Key for Hours

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<tr>
<th>Key for Hours</th>
<th>V</th>
<th>G</th>
<th>U</th>
<th>S</th>
<th>K</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<td>K</td>
<td>colloquium</td>
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### ECTS

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0323-00L</td>
<td>Hands-on Self-Driving Cars with Duckietown</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>M. Di Cicco, A. Censi</td>
</tr>
</tbody>
</table>

*Note: The previous course title until HS20 "Autonomous Mobility on Demand: From Car to Fleet".*

**Abstract**
This course is a hands-on introduction to self-driving cars using the Duckietown platform.

**Objective**
Each student is given a mobile wheeled robot and throughout the class must configure and program.

The objective of the class is to give the student a pragmatic view of what it takes to design and operate a fleet of self-driving cars or any other large robotic systems.

**Content**
Perception, planning, modeling, and control, leveraging primarily on vision data.

**Lecture notes**
Lecture notes, primarily in the form of slides and tutorials, will be accessible from Moodle.

**Literature**
Course notes will be provided in an electronic form. These are some books that can be used to provide background information or consulted as references:
1. Siegwart, Nourbakhsh, Scaramuzza - Introduction to autonomous mobile robots;
2. Norvig, Russell - Artificial Intelligence, a modern approach.
3. Peter Corke - Robotics Vision and Control
4. Oussama Khatib, Bruno Siciliano - Handbook of Robotics

**Prerequisites / notice**
Students should have taken a basic course in probability theory, computer vision, and control systems, and should be familiar and comfortable with programming (Python), Linux, and GIT utilization.

In introduction to ROS will be given, but it's strongly advised that students have prior exposure to and experience with ROS to effectively navigate through the homework assignments and the final project.

A shared space will be available to work with the robots.

It's advised students will have ~5 square meters of free space at their place to work with their assigned robot.

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Adaptability and Flexibility

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<tr>
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<tbody>
<tr>
<td>151-0325-00L</td>
<td>Planning and Decision Making for Autonomous Robots</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>E. Frazzoli</td>
</tr>
</tbody>
</table>

**Abstract**
Planning safe and efficient motions for robots in complex environments, often shared with humans and other robots, is a difficult problem combining discrete and continuous mathematics, as well as probabilistic, game-theoretic, and ethical/regulatory aspects. This course will cover the algorithmic foundations of motion planning, with an eye to real-world implementation issues.

**Objective**
The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments.

**Content**

**Lecture notes**
Course notes and other education material will be provided for free in an electronic form.

**Literature**
There is no required textbook, but an excellent reference is Steve LaValle’s book on “Planning Algorithms.”

**Prerequisites / notice**
Students should have taken basic courses in optimization, control systems, probability theory, and should be familiar with modern programming languages and practices (e.g., Python, and/or C/C++). Previous exposure to robotic systems is a definite advantage.

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Decision-making

<table>
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</thead>
<tbody>
<tr>
<td>151-0371-00L</td>
<td>Advanced Model Predictive Control</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>M. Zeilinger, A. Carron, L. Hewing, J. Köhler</td>
</tr>
</tbody>
</table>

**Abstract**
Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

**Objective**
Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

**Content**
Topics include:
- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of regression methods
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning
Lecture notes will be provided.

Prerequisites / notice
Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control in Spring Semester) strongly recommended. Background in linear algebra and stochastic systems recommended.

151-0509-00L Acoustics in Fluid Media: From Robotics to Additive Manufacturing

Abstract
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices

Lecture notes

Literature

Prerequisites / notice
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-direction and Self-management assessed
- Sensitivity to Diversity fostered
- Negotiation fostered

151-0532-00L Nonlinear Dynamics and Chaos I

Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

151-0563-01L Dynamic Programming and Optimal Control

Abstract
Introduction to Dynamic Programming and Optimal Control.

Objective
 Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature

Prerequisites / notice
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

151-0593-00L Embedded Control Systems

Abstract
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

Objective
Familiarize students with main architectural principles and concepts of embedded control systems.
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

Lecture notes
Lecture notes, lab instructions, supplemental material

Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website
http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

151-0604-00L  Microrobotics  W  4 credits  3G  B. Nelson

Abstract
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisite
The lecture will be taught in English.

151-0615-00L  Real-World Robotics - A Hands-On Project Class  W  4 credits  9A  R. Katzschmann

Abstract
During this course, the students will develop an articulated robotic hand to solve a real-world robotic challenge: the robot must autonomously grasp and place objects. The students will learn the key theoretical concepts required to model, manufacture, control, and test their robot, alongside developing machine learning, programming, hardware, and engineering skills through the hands-on project.

Objective
Learning Objective 2: Robot Design and Simulation
Students will gain experience implementing and simulating robotic systems using modern design, modeling, and simulation techniques such as CAD and Isaac Gym. These techniques are essential in any design process to understand the expected system behavior. This requires thoroughly understanding the system’s kinematics, dynamics, material, actuation principle, and physical limitations. Students will learn the theory and limitations behind modeling and simulation software.

Learning Objective 3: Robot Fabrication
Students will learn to use the previously designed CAD models for successful robot fabrication. Additionally, the iterative nature of the process will allow them to develop their critical thinking skills in assessing the limitations of their design as well as possible sources for improvements. Building the robot will equip students with essential skills for using robots in the real world.

Learning Objective 4: Control, Integration, and Testing
Students can directly apply the knowledge acquired in their control courses. They will gain theoretical knowledge on how to model and develop intelligent control algorithms. Perception methods and state-of-the-art machine-learning techniques will be taught. They will gain experience testing their robots’ performance in both hard- and software to enhance their design and suggest future improvements.

Learning Objective 5: Robot production
Students will learn to choose between state-of-the-art industrial production processes to manufacture a soft robot by understanding their limitations and requirements. They will also learn how to optimize the robot design to account for a specific production process.
During this course, the students will be divided into teams and each group will independently develop an articulated robotic arm to solve a real-world robotic challenge, which will take place at the end of the course. The students will learn the key theoretical concepts required to model, manufacture, control and test a soft robot, along with developing the programming, hardware and engineering skills through hands-on workshops.

This course is composed of tutorials, which will be available on the course website where the lecturer will provide all the necessary theoretical input, focus talks where robotic experts will present a particular aspect of the manipulator in detail, and workshops where the students will have the possibility to hands-on learn how to implement the solutions required to solve their challenge. Finally, there will be time slots to autonomously work on the manufacturing and development of the team's robot and an online forum will be available to help the students throughout the entire course.

This course is divided into six parts:

Part 1: Challenge introduction
- Identify the functional requirements necessary for the final challenge
- Evaluate the existing manipulator designs to optimize them for the specific task

Part 2: Robot Design
- Develop a CAD model based on the high-level system design.
- Integrate motors, pneumatics components, and other required materials in the design

Part 3: Robot Fabrication
- Come up with a fabrication method and plan using the presented fabrication skills.
- Fabricate the robot and its actuators based on the CAD model.
- Evaluate, modify, and enhance the fabrication approach.

Part 4: Soft Robot Simulation
- Simulate the soft manipulator through a simulation framework
- Optimize the simulation parameters to reflect the experimental setup

Part 5: Control, Integration, and Testing
- Formulate the dynamic skills needed for real-life application.
- Develop traditional and learning-based control algorithms and test them in simulation.
- Integrate controller design into the fabricated robot.
- Build, test, fail, and repeat until the soft robot works as desired in simple tasks.
- Upgrade and validate the robot for performance in real-world conditions and verify requirements.

Part 6: Product development
- Propose a manufacturing process to bring the robot from a prototype to the final product
- Optimize the robot for production

Lecture notes
All class materials, including slides, video tutorials, and supporting literature, can be found on the class webpage (https://rwr.ethz.ch) and Moodle, supported by discussion and Q&A forums. Focus talks, Q&A sessions, and workshops will happen on Mondays between 14:00 and 16:00.

Literature


Prerequisites / notice
Students are expected to have attended introductory courses in dynamics, control systems, and robotics.

The graded semester performance consists of the final team performance in the class challenge, a final team presentation and report, weekly Moodle quizzes, and attendance at the focus talks and workshops.

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151-0632-00L Vision Algorithms for Mobile Robotics (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: DINF2039

Mind the enrolment deadlines at UZH:
Abstract
For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry (the algorithms behind Hololens, Oculus Quest, and the NASA Mars rovers).

Objective
Learn the fundamental computer vision algorithms used in mobile robotics, in particular: filtering, feature extraction, structure from motion, multiple view geometry, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry and Simultaneous Localization And Mapping (SLAM) (the algorithms behind Hololens, Facebook-Oculus Quest, and the NASA Mars rovers).

Content
Each lecture will be followed by a lab session where you will learn to implement a building block of a visual odometry algorithm in Matlab.

By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.

Lecture notes
Lecture slides will be made available on the course official website: http://rpg.ifi.uzh.ch/teaching.html

Literature

Prerequisites / notice
Fundamentals of algebra, geometry, matrix calculus, and Matlab programming.

Note: If you are interested in taking UZH courses, you must register as an incoming mobility student at UZH. For details, see as follows:

UZH course enrollment for ETH student at University of Zurich (UZH) > Mobility within Switzerland – Incoming > Module Mobility: The easiest way to take individual courses/courses to supplement your studies at your home university is with module mobility. This option is not available to students who have dropped out of their home university or have been definitely excluded or banned from the relevant program > Application and Deadlines: Applications are submitted via the UZH application portal (https://www.uzh.ch/cmsssi/en/studies/application/chmobilityin.html)

Step-by-step guidelines on how ETH students can register for this course, are given on the official course website: https://rpg.ifi.uzh.ch/teaching.html

ATTENTION: When you book the course at UZH, you are automatically registered for the exam at UZH and you can unregister until the October deadline. After registering for the course, you as an ETH student need to check out your "**UZH email account**" to receive the releated information from the lecturer.

151-0851-00L Robot Dynamics

Abstract
We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

Objective
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Content
The course consists of three parts: First, we will refresh and deepen the student's knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

Prerequisites / notice
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

151-1116-00L Introduction to Aircraft and Car Aerodynamics

Abstract
Aircraft aerodynamics: Atmosphere; aerodynamic forces (lift, drag); thrust.


Objective
An introduction to the basic principles and interrelationships of aircraft and automotive aerodynamics.

To understand the basic relations of the origin of aerodynamic forces (ie lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components, illustration of the intrinsic problems and results using examples. Using experimental and theoretical methods to illustrate possibilities and limits.

Content
Aircraft aerodynamics: atmosphere, aerodynamic forces (ascending force: profile, wings, Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.


Lecture notes
Preparation materials & slides are provided prior to each class

Literature
- Schlichting,H. und Truttenbrodt, E: Aerodynamik des Flugzeuges (Bd I und II), Springer Verlag, 1960

Vehicle Aerodynamics

151-9905-00L Applied Category Theory for Engineering I

Abstract
Applied Category Theory is an exciting multidisciplinary field of research which harnesses the mathematical language of category theory for applications across a broad range of disciplines. This course is a gentle introduction focused on applications in engineering and the "compositional approach" to systems analysis, co-design, and computation.
Objective

1) Learn basic concepts from algebra and category theory, together with ways to make use of these concepts for engineering applications.

2) Become familiar with case studies of applied category theory, for instance involving dynamical systems, databases, and complex system co-design (e.g. in the context of autonomous vehicles).

3) Be able to recognize compositional structures in concrete scenarios at different levels of abstraction.

4) Understand the “compositional way of thinking” as an approach to systems analysis, co-design, and computation.

Content

Review of basic algebraic structures [sets, relations, (semi)groups, monoids, actions, order theory]

Gentle introduction to category theory [series and parallel composition, feedback, actions, functors, universal properties]

Many simple applied examples illustrating concepts along the way. Extended examples from dynamical systems, databases, and systems co-design in engineering.

Homework will consist of 1) basic exercises to check one’s understanding of core concepts, and 2) a choice between either A) coding exercises (in python) to learn how to implement concepts in software or B) further theory exercises to deepen mathematical understanding.

Homework will be graded on a schedule that allows some flexibility, and it will constitute 100% of the grade (no exam).

Lecture notes

Slides and a (work-in-progress) textbook for the course will be provided (A. Censi, J. Lorand, G. Zardini, “Applied Compositional Thinking for Engineers”).

Literature


Supplementary references include the following books:

Fong, Spivak, “An invitation to applied category theory: Seven sketches in compositionality”

Spivak, “Category theory for the sciences”

Prerequisites / notice

A knowledge of algebra at the level of a bachelor’s degree in engineering/computer science.

Competencies

Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Analytical Competencies
Social Competencies: Communication
Personal Competencies: Creative Thinking

Analysis Competencies: Problem-solving

Classified as assessed if you are able to understand, classify, and put concepts into practice.

Fostered if you need to improve your skills in these areas.

Discrete Event Systems

W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer

Abstract

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. Then we analyze discrete event systems from an average-case and from a worst-case perspective, and study verification. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Petri Nets.

Objective

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by exploring the limits of what is computable and what is not. In doing so, we will consider three distinct models of computation which are often used to model discrete event systems: finite automata, push-down automata and Turing machines (ranked in terms of expressiveness power). In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply continuous time markov chains and queueing theory for an understanding of the typical behavior of a system. Then we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queueing. In the last part of the course we introduce methods that allow to formally verify certain properties of Finite Automata and Petri Nets. These are some typical analysis questions we will look at: Do two given systems behave the same? Does a given system behave as intended? Does the system eventually enter a dangerous state?

Content

1. Regular Languages
2. Non-Regular Languages
3. Markov Chains
4. Stochastic Discrete Event Systems
5. Worst-Case Event Systems
6. Verification of Finite Automata
7. Petri Nets

Lecture notes

Available at https://disco.ethz.ch/courses/des/
Abstract
An embedded system is a combination of hardware and software, either fixed in function or programmable, that is designed for a specific application scenario or for a specific task within a larger system. They are part of industrial machines such as agricultural and manufacturing equipment, automotive systems, medical equipment, household appliances, sensor networks, and the Internet of Things.

Objective
Understanding the specific requirements and problems that arise in embedded system applications.

Understanding the hardware structure of a microcontroller and an embedded system; memory architecture and memory map, internal and external peripherals, low-power and low-energy design as well as instruction sets and computational accelerators.

Understanding the firmware structure of a microcontroller and an embedded system; low-level instruction set, hardware-software interfaces, communication between components, embedded real-time operating systems, real-time scheduling, shared resources, low-power and low-energy programming as well as computational accelerators.

Using formal models and methods for designing and optimizing embedded systems.

Gaining experience with practical applications of the C programming language, embedded real-time operating systems, and debug functionalities of the associated design environment to design, implement, and verify embedded firmware.

Through project-based activities, students will gain substantial experience in applying the C programming language in the context of embedded systems. Projects will involve developing and implementing firmware, utilizing embedded real-time operating systems, and exploring the debugging functionalities within design environments. This hands-on approach aims to bridge the gap between theoretical knowledge and practical application, allowing students to experience the full lifecycle of embedded system development from design to implementation and verification.

Content
This lecture focuses on the design of embedded systems using formal models and methods.

Besides the theoretical lecture, the course contains laboratory sessions where students transfer the learned theoretical aspects into praxis by programming a microcontroller and interfacing it with sensors and actuators. Students will be exposed to a commercial microcontroller, and the development board extend with a custom-designed embedded systems educational platform.

Specifically, the following topics will be covered in the course: hardware and software structures of embedded systems, low-level instruction set, memory architecture and memory map, peripherals, hardware-software interfaces, communication between components, firmware design methodologies, firmware design using the C programming language, embedded real-time operating systems, real-time scheduling, shared resources, low-power, and low-energy designs as well as computational accelerators.

Lecture notes
Lecture material, publications, exercise sheets, and laboratory documentation will be available on the course's Moodle page.
Analytical Competencies
Creative Thinking

Concepts and Theories
Techniques and Technologies
assessed
assessed

Subject-specific Competencies

Lecture notes
Available on the course Moodle platform.

Prerequisites / notice
Sufficient mathematical maturity, in particular in linear algebra, analysis.

Competencies

Linear System Theory

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Abstract
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Prerequisites:
- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

Lecture notes
Lecture notes and associated exercises including correct answers.

Literature

Method-specific Competencies
Analytical Competencies
assessed

Problem-solving
assessed

Personal Competencies
Creative Thinking
assessed

Critical Thinking
assessed

Integrity and Work Ethics
assessed

E. Konukoglu
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail; the operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.

Lecture notes
Lecture notes and associated exercises including correct answers.

Prerequisites / notice
- C programming, circuit theory, digital logic, binary number representations.
- Prerequisites: Introductory course on power electronics is recommended.

Competencies

Power Electronic Systems I

Objective
Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems. Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.

Content
- Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail; the operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.

Abstract
The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions.

Prerequisites / notice
- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
- The course language is English.

Competencies

Image Analysis and Computer Vision

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Abstract

Lecture notes
Lecture notes and associated exercises including correct answers.

Prerequisites / notice
- Prerequisites: Introductory course on power electronics is recommended.

Competencies

Power System Analysis

Objective
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Abstract
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Prerequisites:
- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
- The course language is English.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions.

Prerequisites / notice
- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
- The course language is English.
Abstract
The goal of this course is understanding the stationary dependencies in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

Objective
The goal of this course is understanding the stationary dependencies in electrical power systems and the application of analysis tools in normal but also in faulty state.

Content
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis and symmetrical components are discussed as well as power flow computation techniques for distribution grids and state estimation.

Lecture notes
Lecture notes.

Competencies
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227-0560-00L Computer Vision and Artificial Intelligence for Autonomous Cars
W 6 credits 3V+2P C. Sakaridis
Up until FS2022 offered as Deep Learning for Autonomous Driving

Abstract
This course introduces the core computer vision techniques and algorithms that autonomous cars use to perceive the semantics and geometry of their driving environment, localize themselves in it, and predict its dynamic evolution. Emphasis is placed on techniques tailored for real-world settings, such as multi-modal fusion, domain-adaptive and outlier-aware architectures, and multi-agent methods.

Objective
Students will learn about the fundamentals of autonomous cars and of the computer vision models and methods these cars use to analyze their environment and navigate themselves in it. Students will be presented with state-of-the-art representations and algorithms for semantic, geometric and temporal visual reasoning in automated driving and will gain hands-on experience in developing computer vision algorithms and architectures for solving such tasks.

After completing this course, students will be able to:
1. understand the operating principles of visual sensors in autonomous cars
2. differentiate between the core architectural paradigms and components of modern visual perception models and describe their logic and the role of their parameters
3. systematically categorize the main visual tasks related to automated driving and understand the primary representations and algorithms which are used for solving them
4. critically analyze and evaluate current research in the area of computer vision for autonomous cars
5. practically reproduce state-of-the-art computer vision methods in automated driving
6. independently develop new models for visual perception

Content
The content of the lectures consists in the following topics:

1. Fundamentals
   (a) Fundamentals of autonomous cars and their visual sensors
   (b) Fundamental computer vision architectures and algorithms for autonomous cars

2. Semantic perception
   (a) Semantic segmentation
   (b) Object detection
   (c) Instance segmentation and panoptic segmentation

3. Geometric perception and localization
   (a) Depth estimation
   (b) 3D reconstruction
   (c) Visual localization
   (d) Unimodal visual/lidar 3D object detection

4. Robust perception: multi-modal, multi-domain and multi-agent methods
   (a) Multi-modal 2D and 3D object detection
   (b) Visual grounding and verbo-visual fusion
   (c) Domain-adaptive and outlier-aware semantic perception
   (d) Vehicle-to-vehicle communication for perception

5. Temporal perception
   (a) Multiple object tracking
   (b) Motion prediction

The practical projects involve implementing complex computer vision architectures and algorithms and applying them to real-world, multi-modal driving datasets. In particular, students will develop models and algorithms for:

1. Semantic segmentation and depth estimation
2. Sensor calibration for multi-modal 3D driving datasets
3. 3D object detection using lidars
4. Motion prediction
5. Temporal perception
6. Independent development of new models for visual perception

Lecture notes
Lecture slides are provided in PDF format.

Prerequisites / notice
Students are expected to have a solid basic knowledge of linear algebra, multivariate calculus, and probability theory, and a basic background in computer vision and machine learning. All practical projects will require solid background in programming and will be based on Python and libraries of it such as PyTorch.

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Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing.

No lecture notes, but slides will be made available on the course webpage.

**227-0689-00L** System Identification

| Abstract | Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data. |
| Objective | To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity. |
| Prerequisites / notice | Control systems (227-0216-00L) or equivalent. |

**227-0697-00L** Industrial Process Control

| Abstract | General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends. |
| Objective | Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering. Differences and characteristics of discrete and process industries. |
| Content | Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry. |
| Lecture notes | Slides will be available as .PDF documents. |
| Literature | References will be given at the end of individual lectures. |
| Prerequisites / notice | Exercises: Tuesdays after the lecture (applies not to all lectures) |
| Competencies | Subject-specific Competencies Concepts and Theories assessed |

**252-0535-00L** Advanced Machine Learning

| Abstract | Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects. |
| Objective | Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data. |
| Content | The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data. |
| Lecture notes | No lecture notes, but slides will be made available on the course webpage. |

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The seminar "Advanced Topics in Machine Learning" familiarizes students with recent developments in pattern recognition and machine learning. Possible topics include:

- Reinforcement learning
- Multi-armed bandits and Bayesian optimization
- Probabilistic planning (MDPs, POMPDPs)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic inference (variational inference, MCMC)
- Probability

This seminar covers advanced topics in computer vision, such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics. Each time the course is offered, a collection of research papers is selected and each student presents one paper to the class and leads a discussion about the paper and related topics.

Content
The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from the computer vision or bioinformatics - two fields, which rely more and more on machine learning methodology and statistical models.

The papers will be presented in the first session of the seminar.

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the assessment fostered Computer Vision Z. Bauer

Subject-specific Competencies

Mixed Reality

Physical Human Robot Interaction \((pHRI)\)  ■ W 4 credits 2V+2U O. Lambercy, P. Wolf

Abstract

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

Objective

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de-sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Content

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes

Will be distributed on Moodle before the lectures.
Literature


Prerequisites / notice

The registration is limited to 26 students

The students are expected to have basic control knowledge from previous classes.

http://www.relab.ethz.ch/education/courses/phri.html

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed

Social Competencies

Communication assessed

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Self-direction and Self-management fostered

636-0007-00L

Computational Systems Biology

W 6 credits 3V+2U J. Stelling

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Content

Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes

http://www.csb.ethz.ch/education/lectures.html

Literature


Multidisciplinary Courses

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Any courses offered by the Departments of MAVT, ITET or INFK. Your tutor must agree to this choice.

151-0623-00L ETH Zurich Distinguished Seminar in Robotics, Systems and Controls

**Type**: W
**ECTS**: 1 credit
**Hours**: 1S

**Lecturers**: B. Nelson, M. Hutter, R. Katzschmann, C. Menon, R. Riener, R. Siegwart

**Abstract**
This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls.

**Objective**
Obtain an overview of various topics in Robotics, Systems, and Controls from leaders in the field. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a list of upcoming lectures.
### Key for Hours

<table>
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<th>Key</th>
<th>Description</th>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>lecture with exercise</td>
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<td>practical/laboratory course</td>
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<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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**ECTS**

- European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Science, Technology, and Policy Master

Social Sciences

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<th>Number</th>
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**Abstract**
This course teaches the basics of public opinion surveys. We start with the theoretical foundations of the formation of (public) opinion formation and ideology, then turn to the practical lessons of developing and implementing own surveys with a focus on causal inference via survey experiments. Finally, we give practical insights into the analysis of (complex) survey data.

**Objective**
The goals of this class are:
- to understand the basics of public opinion research
- to translate this theoretical knowledge into the practical design and implementation of surveys
- to make use of survey experiments for causal inference

At the end of the course, students should be able to use and evaluate public opinion data and design survey experiments to test policy-relevant questions.


**Abstract**
This course first provides a broad conceptual and historical perspective on technological and scientific innovation, and then focuses on different modes of policy analysis and their application to policy questions in a variety of areas.

**Objective**
This course picks up on the ISTP Cornerstone course in Science, Technology and Policy and goes into greater depth on issues covered in that course, as well as additional issues where science and technology are among the causes of societal challenges but can also help in finding solutions.

**Content**
See the program on the ISTP website: http://www.istp.ethz.ch/events/colloquium.html

| 860-0005-00L | Colloquium Science, Technology, and Policy (HS) | O    | 1 credit | 1K    | T. Schmidt, T. Bernauer, E. Tilley |

**Abstract**
Presentations by guest speakers from academia and practice/policy. Students are assigned to play a leading role in the discussion and write a report on the respective event.

**Objective**
Students obtain insights into different policy-related research fields and participate in scientific discussions.

**Content**
See the program on the ISTP website: http://www.istp.ethz.ch/events/colloquium.html

**Prerequisites / notice**
The series is open to the public. The lectures start at 12:15 and last 30 minutes, followed by an open discussion of 30 minutes.

| 860-0031-00L | Policy Analysis | O    | 4 credits | 2V    | B. Steffen, T. Schmidt, to be announced |

**Abstract**
The course Policy Analysis 1 will introduce important concepts and methods for ex-ante policy analysis. It will mostly focus on the policy content (vis-à-vis the policy process). We will primarily discuss quantitative methods. The course will contain several practical assignments in which students have to apply the concepts and methods studied.

**Objective**
Students should gain the skill to perform policy analyses independently. To this end, students will be enabled to understand a policy problem and the rationale for policy intervention; to select appropriate impact categories and methods to address a policy problem through policy analysis; to assess policy alternatives, using various ex-ante policy analysis methods; and to communicate the results of the analysis.

| 363-0503-00L | Principles of Microeconomics | O    | 3 credits | 2G    | M. Filippini |

**Abstract**
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

**Objective**
The learning objectives of the course are:
(1) Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externality related to market activities and illustrate how these affect the economy as a whole. (5) Students can recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

For students taking only the course ‘Principles of Microeconomics’ there is a shorter version of the same book:

Complementary:
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Content
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

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Complementary:
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
Public policies result from decision-making processes that take place within formal institutions of the state (parliament, government, public
organisations). The third module (Frank Schimmelfennig) focuses on the European Union and international organisations.

They learn why and how public policies and laws are developed, designed, and implemented at national and international levels, and what challenges arise in this regard. The course is organized in three modules. The first module (Stefan Bechtold) examines basic concepts and the role of law, law-making, and law enforcement in modern societies. The second module (Thomas Bernauer) deals with the functioning of legislatures, governments, and interest groups. The third module (Frank Schimmelfennig) focuses on the European Union and international organisations.

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

860-0001-00L Public Institutions and Policy-Making Processes
Number of participants limited to 35.
Priority for Science, Technology, and Policy Master.

Abstract
Students acquire the contextual knowledge for analyzing public policies. They learn why and how public policies and laws are developed, designed, and implemented at national and international levels, and what challenges arise in this regard.

Objective
Public policies result from decision-making processes that take place within formal institutions of the state (parliament, government, public administration, courts). That is, policies are shaped by the characteristics of decision-making processes and the characteristics of public institutions and related actors (e.g. interest groups). In this course, students acquire the contextual knowledge for analyzing public policies. They learn why and how public policies and laws are developed, designed, and implemented at national and international levels, and what challenges arise in this regard. The course is organized in three modules. The first module (Stefan Bechtold) examines basic concepts and the role of law, law-making, and law enforcement in modern societies. The second module (Thomas Bernauer) deals with the functioning of legislatures, governments, and interest groups. The third module (Frank Schimmelfennig) focuses on the European Union and international organisations.

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 lotion
Course materials can be found on Moodle.

Lecture notes
Readings can be found on Moodle.

Prerequisites / notice
This is a Master level course. The course is capped at 27 students, with ISTP Master students having priority.

860-0008-00L MSc STP Introductory Day

Abstract
The course gives an overview of the structure of the MSc STP programme and the content of the obligatory courses in social sciences.

Objective
Students learn about the structure of the study programme, the different types of courses and how to select courses within the various course categories.

Competencies
Subject-specific Competencies
Concepts and Theories
- fostered

Literature
Basic literature and references are listed on the webpage.

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The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

In Autumn Semester 2024, the course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group. Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

### Competencies

#### Subject-specific Competencies

**Concepts and Theories**
- assessed

**Techniques and Technologies**
- assessed

#### Method-specific Competencies

**Analytical Competencies**
- assessed

**Problem-solving**
- assessed

**Project Management**
- fostered

**Communication**
- fostered

**Cooperation and Teamwork**
- assessed

**Negotiation**
- fostered

**Adaptability and Flexibility**
- fostered

**Critical Thinking**
- assessed

**Self-direction and Self-management**
- fostered

### Prerequisites / notice

More specifically upon completion of the course, students had their first experience with
- defining the service to be provided by infrastructure,
- developing and evaluating asset strategies, and converting them into programs / project portfolios
- establishing a monitoring program for an infrastructure system, and
- establishing basic rules and principles to ensure an infrastructure management organisation is running well.
The weekly lectures are structured as follows:

1. Introduction: An introduction to infrastructure management and the project.
2. Service: Determination of what service you are trying to provide with an infrastructure network is important in justifying the interventions you think are required and ensuring that investment decisions are aligned throughout an infrastructure management organisation. This lecture introduces the concept of service and connects it to measurable indicators.
3. Help session 1: This session provides time for your group to ask questions as you define the service you want your infrastructure network to provide.
4. Presentation 1: 4 groups will present their ideas on how they want their networks to provide service.
5. Interventions: Justifying the interventions you want to execute to ensure you continue to provide the defined service requires you to model deterioration, determining economically justifiable strategies and explain which interventions will be postponed if you can't do all you would like. This lecture is focused on explaining the main principles behind each of these concepts.
6. Help session 2: This session provides time for your group to ask questions as you justify the interventions you want to execute on your infrastructure network over time and explain what you will postpone if you cannot do all of them.
7. Presentation 2: 4 groups will present how they have justified interventions and how they have selected the ones they would like to postpone if required.
8. Monitoring: To ensure you the infrastructure network is providing what you expect you need to monitor its performance and how projects are being done. This lecture is focused on the principles to ensure a monitoring system is set up that ensure that the infrastructure system is providing the expected service.
9. Help session 3: This session provides time for your group to ask questions on how to establish the monitoring systems for your infrastructure networks.
10. Presentation 3: 4 groups will present how they intended to monitor their systems and projects.
11. Organisation: Managing infrastructure only works well with great teams of people with great processes. This lecture focuses on the principles of ensuring a well functioning organisation and well-functioning processes.
12. Help session 4: This session provides time for your group to ask questions on how to ensure well-functioning organisations and well-functioning processes.
13. Presentation 4: 4 groups will present how they intended to ensure well-functioning organisations and well-functioning processes.

Lecture notes:
- The lecture materials consist of handouts and the slides.
- The lecture materials will be distributed via Moodle by the beginning of each lecture.
- The questions to be discussed in the discussion session will be distributed by the end of the day on the Monday before the discussion session.

Literature:
Appropriate literature will be handed out when required via Moodle.

Prerequisites / notice:
This course has no prerequisites.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving fostered
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

103-0347-01L Landscape Planning and Environmental Systems (GIS W 3 credits 2U A. Grêt-Regamey, C. Brouillet, N. Klein, I. Nicholson Thomas

Abstract
The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

Objective
- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies
- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

Lecture notes
A script and presentation slides for each exercise will be provided on Moodle.

Literature
Will be named in the lecture.

Prerequisites / notice
Basic GIS skills are strongly recommended.
Abstract
In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

Objective
The aims of this course are:
1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.

Content
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Lecture notes
No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites / notice
The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered
Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered
Objective
Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks.
Their various performance criteria based on various perspective and stakeholders.
The most relevant decision making problems in a planning tactical and operational point of view
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies,
system design and line planning for different situations,
mathematical models for design and line planning
timetabling and tactical planning, and related mathematical approaches
operations, and quantitative support to operational problems,
evaluation of public transport systems.

Content
Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes
Lecture slides are provided.

Literature
Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
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Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Spatial Planning and Development W 3 credits 2G D. Kaufmann, A. Kuitenbrouwer
Only for master students, otherwise a special permission by the lecturer is required.

Abstract
The course deals with theoretical, methodological and practical foundations around the understanding and production of urban space. It discusses theoretical planning frameworks, and tasks of spatial planning at various scales, addresses current and future challenges of spatial development and reviews approaches for a sustainable development in Switzerland and beyond.
Objective
The overall aim of the course is to raise students' awareness and curiosity about the aspects that guide and shape our environment. Through lectures, readings, discussions, and exercises, the course seeks to achieve this goal by accumulating crucial notions from both theoretical and practice-based examples, and applying such knowledge into tasks of spatial planning. At the end of this course, students should feel empowered to critically engage with the teaching topic from a variety of approaches. By taking up the lecture, the students should be able to to analyse, interpret and reflect complex cross-scale tasks of spatial development and transformation, and to use their theoretical, methodical and professional knowledge to tackle them.

You as students will...
... assess present and future core challenges of spatial planning and development.
... discuss the role of spatial planning and development in shaping our living environment.
... differentiate the levels, scales and tasks of spatial planning instruments and processes.
... reflect on theoretical concepts and practical examples of decision-making of spatial tasks.
... identify and apply spatially relevant principles and systems for action-oriented planning and decision-making.
... acquire theoretical, methodological, practical know-how to examine, clarify, and solve tasks on spatial development.

Content
Spatial development as a discipline deals with the development, (trans)formation, and arrangement of our urban environment. We simultaneously perceive and contribute to its transformation, making space the result of manifold intended and unintended changes. To mediate between different demands, interests and interventions of multiple actors, a forward-looking, evidence-based, and action-oriented planning is necessary. As guidance for future action, (spatial) planning has to be committed to the sustainable handling as well as just allocation of resources, in particular of the non-replicable resource land.

The course focuses on both theoretical concepts and practice-oriented approaches to gain knowledge and be equipped to address current issues in spatial planning and development. This is mirrored in the course's structure made of both of lectures and exercises.

The lecture series introduces necessary key concepts and covers the following main topics:
- Drivers of spatial development, inward development, core tasks and current challenges for (spatial) planners.
- Interplay of formal and informal planning instruments across scales and actors.
- Differentiation urban typologies, their characteristics and challenges.
- Types of spatial analysis and key figures.
- Planning approaches and the (political) steering of spatial development.
- Types of processes and participation in spatial development.
- Approaches for planning complex urban situations.
- Concepts for sustainable development.

The exercises provide a framework for practical application of the learned theoretical concepts of spatial planning to real-life situations.

The exercises provide a framework for practical application of the learned theoretical concepts of spatial planning to real-life situations.

Lecture notes
A course will be set up on Moodle for the provision of lectures and documents, to upload group deliverables and to ask questions in a discussion Forum. All documents provided are exclusively available for use within this course.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

052-0707-00L Urban Design III W 2 credits 2V H. Klumpner. F. T. Salva Rocha Franco

Abstract
Students are introduced to a narrative of 'Urban Stories' through a series of three tools driven by social, governance, and environmental transformations in today's urbanization processes. Each lecture explores one city's spatial and organizational ingenuity born out of a particular place's realities, allowing students to transfer these inventions into a catalog of conceptual tools.

Objective
How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.
Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where these have been introduced and implemented, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

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<tr>
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<td>151-0216-00L</td>
<td>Wind Energy</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>N. Chokani</td>
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<tr>
<td>Abstract</td>
<td>The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy. These subjects are introduced through a discussion of the basic principles of wind energy generation and conversion, and a detailed description of the broad range of relevant technical, economic and environmental topics.</td>
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<tr>
<td>Content</td>
<td>This mechanical engineering course focuses on the technical aspects of wind turbines; non-technical issues are not within the scope of this technically oriented course. On completion of this course, the student shall be able to conduct the preliminary aerodynamic and structural design of the wind turbine blades. The student shall also be more aware of the broad context of drivetrains, dynamics and control, electrical systems, and meteorology, relevant to all types of wind turbines.</td>
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<td>227-0731-00L</td>
<td>Power Market I - Portfolio and Risk Management</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>D. Reichelt, G. A. Koeppe</td>
</tr>
<tr>
<td>Abstract</td>
<td>Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2265 of 2667
The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and...1.6% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to...should be able to answer after having completed the course.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transport networks. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

In the course, students will be able to answer questions such as: How does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transport networks. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

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In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.
Physical fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding.

Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.

Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of reactor technology.


R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

### 151-1633-00L Energy Conversion

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
<th>L. Karlin, G. Sansavini, S. A. Hosseini</th>
</tr>
</thead>
</table>

**Abstract**

This course is intended for students outside of D-MAVT.

This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.

**Objective**

Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course is to give a compact introduction into basics of Thermodynamics: Thermodynamic states and thermodynamic processes; Work and Heat; First and Second Laws of Thermodynamics. Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to building up students’ intuition about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibrium. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included.

In the course "Energy Conversion", the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

**Content**

1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

**Lecture notes**

Lecture slides and supplementary documentation will be available online.

**Literature**


**Prerequisites / notice**

This course is intended for students outside of D-MAVT.

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>assessed</td>
</tr>
<tr>
<td>Problem Management</td>
<td>Self-presentation and Social Influence</td>
<td>Leadership and Responsibility</td>
<td>assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Self-reflection</td>
<td>assessed</td>
</tr>
<tr>
<td>Chemical reactions and combustion systems</td>
<td>Negotiation</td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
</tr>
<tr>
<td>chemical and phase equilibrium</td>
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</table>

**151-0567-00L Engine Systems**

<table>
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<tr>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
<th>B.V.</th>
</tr>
</thead>
</table>

**Abstract**

Introduction to current and future engine systems and their control systems

Introduction to methods of control and optimization of dynamic systems. Application to real engines. Understand the structure and behavior of drive train systems and their quantitative descriptions.

**Objective**

Physical description and mathematical models of components and subsystems (mixture formation, load control, supercharging, emissions, drive train components, etc.)

**Content**

Case studies of model-based optimal design and control of engine systems with the goal of minimizing fuel consumption and emissions.

**Lecture notes**

Introduction to Modeling and Control of Internal Combustion Engine Systems

Guzzella Lino, Onder Christopher H.


ISBN: 978-3-642-10774-0

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2267 of 2667
Introduction to Electric Power Transmission: System & Technology

**Abstract**
Introduction to theory and technology of electric power transmission systems.

**Objective**
At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of lines, know about electrical safety, calculate electric withstand strength of gas gaps, stationary power flows and other basic parameters in simple power systems.

**Content**
Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principle of electric power systems.

**Lecture notes**
Lecture script in English, exercises and sample solutions.

---

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

**Social Competencies**
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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**Data and Computer Science**

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<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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<td>263-3210-00L</td>
<td>Deep Learning</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>T. Hofmann</td>
</tr>
</tbody>
</table>

**Abstract**
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

**Prerequisites / notice**
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/

  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/

  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19

  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/

  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php

  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

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<td>252-1414-00L</td>
<td>System Security</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>S. Capkun, S. Shinde</td>
</tr>
</tbody>
</table>

**Abstract**
The first part of the course covers general security concepts and hardware-based support for security.

**Objective**
In the second part, the focus is on system design and methodologies for building secure systems.

In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

### Competencies

<table>
<thead>
<tr>
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<td>Decision-making</td>
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<td>fostered</td>
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<td>Problem-solving</td>
<td>fostered</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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### Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

### Objective
- Students are familiar with fundamental network-security concepts.
- Students can implement network-security protocols based on cryptographic libraries.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students can assess current threats that Internet services and networking devices face, and can evaluate appropriate countermeasures.
- Students can apply knowledge of network security to design and implement secure systems.
- Students have an in-depth understanding of the most important cryptographic primitives.
- Students can assess current threats that Internet services and networking devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.

### Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
1. Network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems.
2. Network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks.
3. Analysis and inference topics such as traffic monitoring and network forensics.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

### Prerequisites / notice
This course is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L.

Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

**Topics covered in the lecture include:**

**Lecture notes**
No lecture notes, but slides will be made available on the course webpage.

**Literature**

**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### 263-2400-00L Reliable and Trustworthy Artificial Intelligence

**Abstract**
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

**Objective**
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

**Content**
- **Robustness of Machine Learning**
  - Adversarial attacks and defenses on deep learning models.
  - Certified training of deep neural networks (combining symbolic and continuous methods).

- **Privacy of Machine Learning**
  - Threat models (e.g., stealing data, poisoning, membership inference, etc.).
  - Attacking federated machine learning (across vision, natural language and tabular data).
  - Differential privacy for defending machine learning.
  - AI Regulations and checking model compliance.

- **Fairness of Machine Learning**
  - Introduction to fairness (motivation, definitions).
  - Enforcing individual fairness (for both vision and tabular data).
  - Enforcing group fairness (e.g., demographic parity, equalized odds).

**Robustness, Privacy and Fairness of Foundation Models**

- We discuss all previous topics, as well as programmability, in the context of latest foundation models (e.g., LLMs).


**Prerequisites / notice**
While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical and computational approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

The list of papers will be provided at the beginning of the course.

The course requires that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

This seminar course is designed to provide students with an opportunity to review and critically evaluate recent publications in medical field focusing on examples when CS method or bioinformatics/statistical technique has lead to an instrumentation, technique or drug approved for clinical practice use.

Throughout the course, students will read and analyze recent publications that demonstrate successful applications and sometimes failures in medicine. Promissing research applications will also be discusssed. The publications will cover a wide range of topics, including drug discovery, image analysis, prognostic models, and learning healthcare.
The course will be structured as half lecture content and half seminar content. Lectures will review state of the medical practice prior to the discovery, obstacles in moving the field forward, and the need for improvement. Lecture will be followed by the seminar part where students will take turns presenting the assigned publications and leading the discussions. Students’ presentations will focus on the main findings, and specific steps taken to translate the finding into clinical practice.

Publications will include examples of:
- specific CS/bioinformatics/statistics applications that has been brought to ‘bedside’ – has been approved by European Medicines Agency / Food and Drug Administration (USA) for clinical use or are widely used in medical research;
- examples of failures of how a discovery did not translate into an endproduct and why;
- current active research areas.

Covered topics will include some of the following:
- Drug discovery: Computer-aided drug discovery has become an integral part of the drug development process, enabling researchers to design and screen large libraries of molecules in silico (i.e., using computer simulations) before synthesizing and testing them in the lab. This has led to the discovery of new drug candidates for a wide range of diseases, including cancer, Alzheimer’s disease, and HIV/AIDS.
- Genomics: Advances in computational genomics have enabled researchers to analyze and interpret large-scale genomic data, including DNA sequencing data, to identify disease-causing mutations, genetic risk factors, and drug targets. Examples of the development of personalized medicine, where treatments are tailored to an individual’s genetic makeup. Examples when drug target identified by genetics has led to approved treatment.
- Imaging: Computer vision and image processing techniques have revolutionized medical imaging, enabling researchers to extract quantitative information from medical images that were previously inaccessible. This has led to the development of new diagnostic and prognostic tools for a wide range of diseases, including cancer, cardiovascular disease, and neurological disorders.
- Real-world data applications: emulation of clinical trials using electronic health records data.
- Large language models: Generating clinical trial protocols using large language models. Natural Language Processing for information extraction and interpretation.
- Learning healthcare systems: Advances in data analytics and information technology have enabled the development of learning healthcare systems, which use real-time data from electronic health records, medical devices, and other sources to improve patient outcomes and reduce healthcare costs. This has the potential to transform the way healthcare is delivered, making it more personalized, efficient, and effective.

In addition to the presentations, students will also be required to write critical reviews of the assigned publications throughout the course. The reviews will be evaluated based on the students’ ability to identify the strengths and weaknesses of the publications and to provide insightful and constructive feedback.

Prerequisites / notice
The course is intended for advanced undergraduate and graduate students with a background in computer science, bioinformatics, or a related field and interest in applying their skills to medical research.

This course assumes a working knowledge of R/Python and intermediate statistical analysis, including linear, logistic, survival regressions or ability and interest to learn them outside of the class.

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<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>Analytical Competencies</th>
<th>Communication</th>
<th>Cooperation and Teamwork</th>
<th>Leadership and Responsibility</th>
<th>Self-presentation and Social Influence</th>
<th>Sensitivity to Diversity</th>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
<th>Integrity and Work Ethics</th>
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<td>Subject-specific Competencies</td>
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<td>Personal Competencies</td>
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**Life Science and Health**

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-0021-00L</td>
<td>Materials and Mechanics in Medicine</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Zenobi-Wong, J. G. Snedeker</td>
</tr>
<tr>
<td>Abstract</td>
<td>Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.</td>
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<tr>
<td>Objective</td>
<td>Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.</td>
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<tr>
<td>Content</td>
<td>Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.</td>
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<tr>
<td>Lecture notes</td>
<td>course website on Moodle</td>
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<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>W</td>
<td>4</td>
<td>4V</td>
<td>V. Vogel, further lecturers</td>
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<tr>
<td>Abstract</td>
<td>Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.</td>
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<tr>
<td>Objective</td>
<td>Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nanochemistry, nano-mechanics and other properties within mammade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.</td>
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<td>The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.</td>
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<td>Each lecturer will first give an overview of the state-of-the-art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2272 of 2667
Content
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes
All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

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<th>Course Code</th>
<th>Course Title</th>
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<td>Biocompatible Materials</td>
<td>W</td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>Introduction to molecules used for biomaterials,</td>
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<td>molecular interactions between different materials</td>
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<td>and biological systems (molecules, cells, tissues).</td>
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<td>The concept of biocompatibility is discussed and</td>
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<td>important techniques from biomaterials research</td>
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<td>and development are introduced.</td>
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<td>The course covers the following topics:</td>
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<td>1. Introduction into molecular characteristics</td>
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<td>of molecules involved in the materials-to-biology</td>
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<td>interface. Molecular design of biomaterials.</td>
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<td>2. The concept of biocompatibility.</td>
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<td>3. Introduction into methodology used in biomaterials</td>
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<td>research and application.</td>
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<td>4. Introduction to different material classes in</td>
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<td>use for medical applications.</td>
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<td><strong>Content</strong></td>
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<td>Introduction into natural and polymeric biomaterials</td>
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<td>used for medical applications. The concepts of</td>
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<td>biocompatibility, biodegradation and the</td>
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<td>consequences of degradation products are</td>
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<td>discussed on the molecular level. Different</td>
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<td>classes of materials with respect to potential</td>
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<td>applications in tissue engineering, drug delivery</td>
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<td>and for medical devices are introduced. Strong</td>
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<td>focus lies on the molecular interactions</td>
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<td>between materials having very different bulk and</td>
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<td>or surface chemistry with living cells, tissues</td>
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<td>and organs. In particular the interface</td>
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<td>between the materials surfaces and the eukaryotic</td>
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<td>cell surface and possible reactions of the cells</td>
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<td>with an implant material are elucidated.</td>
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<td>Techniques to design, produce and characterize</td>
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<td>materials in vitro as well as in vivo analysis</td>
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<td>of implanted and explanted materials are</td>
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<td>discussed.</td>
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<td>A link between academic research and industrial</td>
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<td>entrepreneurship is demonstrated by external guest</td>
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<td>speakers, who present their current research</td>
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<td>topics.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Handouts are deposited online (moodle).</td>
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<td><strong>Literature</strong></td>
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<td>Literature:</td>
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<td>- Biomaterials Science: An Introduction to</td>
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<td></td>
<td>Materials in Medicine, Ratner B.D. et al, 3rd</td>
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<td></td>
<td>- Comprehensive Biomaterials, Ducheyne P. et al.,</td>
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<td>(available online via ETH library)</td>
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<td>376-0300-00L</td>
<td>Essentials in Translational Science</td>
<td>W</td>
<td>3</td>
<td>2G</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Translational science is a cross disciplinary</td>
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<td>scientific research that is motivated by the need</td>
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<td>for practical applications that help people (e.g.</td>
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<td>Medicines). The course should help to clarify</td>
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<td>basics of translational science, illustrate</td>
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<td>successful applications and enable students to</td>
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<td>integrate key features into their future projects.</td>
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<td><strong>Objective</strong></td>
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<td>After completing this course, students will be</td>
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<td>able to understand:</td>
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<td>Principles of translational science including</td>
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<td>medical device development, intellectual property,</td>
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<tbody>
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<td>Epidemiology and Prevention</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The module Epidemiology and prevention describes</td>
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<td>the process of scientific discovery from the</td>
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<td>detection of a disease and its causes, to the</td>
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<td>development and evaluation of preventive and</td>
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<td>treatment interventions and to improved</td>
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<td>population health.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>The overall goal of the course is to introduce</td>
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<td>students to epidemiological thinking and methods,</td>
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<td>which are critical pillars for medical and</td>
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<td>public health research. Students will also come</td>
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<td>to aware on how epidemiological facts are used</td>
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<td>in prevention, practice and politics.</td>
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Content
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Project Management
- Method-specific Competencies
  - Communication
  - Cooperation and Teamwork
- Social Competencies
  - Creative Thinking
  - Critical Thinking
- Personal Competencies
  - Communication
  - Critical Thinking

752-6151-00L Public Health Concepts
- Objective
  - At the end of this module students are able:
    - to interpret the results of epidemiological studies
    - to critically assess scientific literature
    - to know the definition, dimensions and determinants of health
    - to plan public health interventions and health promotion projects
    - to draw a bridge from evidence to policies and politics
- Content
  - Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition).
- Lecture notes
  - Handouts are provided to students in the classroom.

636-0109-00L Stem Cells: Biology and Therapeutic Manipulation
- Objective
  - Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.
- Content
  - Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.
  - Topics will include:
    - Embryonic and adult stem cells and their niches
    - Induced stem cells by directed reprogramming
    - Relevant basic cell biology and developmental biology
    - Relevant molecular biology
    - Cell culture systems
    - Cell fates and their molecular control by transcription factors and signalling pathways
    - Cell reprogramming
    - Disease modelling
    - Tissue engineering
    - Biomaging, Bioinformatics
    - Single cell technologies
- Competencies
  - Subject-specific Competencies
    - Concepts and Theories
    - Analytical Competencies
    - Decision-making
  - Method-specific Competencies
    - Techniques and Technologies
    - Media and Digital Technologies
  - Social Competencies
    - Communication
    - Cooperation and Teamwork
  - Personal Competencies
    - Critical Thinking
    - Integrity and Work Ethics

376-0225-00L Critical Appraisal of Evidence for Exercise in Health
- Objective
  - On completion of this course students will be able to:
    1. understand the role of physical activity and sedentary behavior in the maintenance of health and the etiology, prevention and treatment of disease
    2. synthesize effective physical activity and exercise interventions for the prevention and management of several diseases and populations
    3. evaluate recent evidence regarding physical activity and exercise interventions
New trends in physical activity for prevention and rehabilitation
Introduction to critical appraisal tools
Exercise for Cancer Rehabilitation
Exercise for Musculoskeletal Rehabilitation (Focus on Osteoarthritis and Low Back Pain)
Exercise in Parkinson’s disease
Exercise for Rehabilitation of Metabolic Disorders (Focus on Obesity and Diabetes type 2)
Exercise for age-related diseases and disorders, Part A (Focus on Frailty and Falls)
Exercise for Stroke Rehabilitation
Exercise in Dementia and Mild Cognitive Impairment
Exercise for Rehabilitation of Metabolic Disorders (Focus on Obesity and Diabetes type 2)
Exercise for age-related diseases and disorders, Part B (Focus on Sarcopenia and Osteoporosis)
Exercise for Cardiovascular Rehabilitation (Focus on Heart Failure)

**Literature**

**Competencies**

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<tr>
<th>Subject-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
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<td>103-0347-00L</td>
<td>Landscape Planning and Environmental Systems</td>
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<td>A. Grêt-Regamey</td>
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**Abstract**
In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

**Objective**
The aims of this course are:
1. To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna);
2. To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning;
3. To show the importance of ecosystem services.
4. To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5. To identify and measure the characteristics of landscape.
6. Learn how to use spatial data in landscape planning.

**Content**
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

**Lecture notes**
No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

**Prerequisites / notice**
The contents of the course will be illustrated in the associated course 103-0347-01U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.
Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

701-1346-00L Climate Change Mitigation: Carbon Dioxide Removal W 3 credits 2G N. Gruber, C. Brunner

Future climate change can only kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.
From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

Lecture notes
None

Literature
Will be identified based on the chosen topic.

Prerequisites / notice
Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

Competencies

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Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered

Abstract
The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

Objective
- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies

Content
- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

Lecture notes
A script and presentation slides for each exercise will be provided on Moodle.

Literature
Will be named in the lecture.

Prerequisites / notice
Basic GIS skills are strongly recommended.

Competencies

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Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

Abstract
The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:
- observational datasets, observation and detection of climate change;
- underlying physical processes and feedbacks;
- numerical and statistical approaches;
- currently available projections.

Objective
At the end of this course, participants should:
- understand the key physical processes shaping climate change in Europe;
- know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
- be familiar with relevant observational and modeling data sets;
- be able to tackle simple climate change questions using available data sets.
### Subject-specific Competencies

#### Contents:
- global context
- observational data sets, analysis of climate trends and climate variability in Europe
- global and regional climate modeling
- statistical downscaling
- key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects
- projections of European and Alpine climate change

#### Notes handed out during lectures
- Slides and lecture notes will be made available at [http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html](http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html)

#### Prerequisites / notice
- Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Contact Hours</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4037-00L</td>
<td>Mineral Resources I</td>
<td>3</td>
<td>W</td>
<td>C. Cheelle-Michou, L. Tavazzani</td>
</tr>
<tr>
<td>751-5201-10L</td>
<td>Tropical Cropping Systems, Soils and Livelihoods (with Excursion)</td>
<td>5</td>
<td>W</td>
<td>J. Six, K. Benabderrazik</td>
</tr>
</tbody>
</table>

### Social Competencies

- Self-presentation and Social Influence
- Leadership and Responsibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management
- Negotiation
- Sensitivity to Diversity
- Self-presentation and Social Influence
- Leadership and Responsibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management
- Negotiation
- Sensitivity to Diversity

### Content

#### Objective
- Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
- Interdisciplinary analysis of agricultural production systems
- Knowledge on methods to assess agroecological performance of a tropical agroecosystems
- Hands-on training on the use of field methods, diagnostic tools and survey methods.
- Gain practical knowledge on how to assess to climate resilience and farming systems.
- Collaboration in international students and stakeholders

#### Abstract
This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in the Mount Kenya Region, which is co-organized with the University of Embu (Kenya).

From October 28th to November 11th, The students will take part in a field course in the Mount Kenya Region. Students will then gain practical knowledge on field, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 18rd 2023, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

#### Prerequisites / notice
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#### Competencies

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<tr>
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<tbody>
<tr>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<td>Critical Thinking</td>
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<tr>
<th>Competencies</th>
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<tr>
<td>Communication</td>
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<tr>
<td>Decision-making</td>
<td>fostered</td>
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<tr>
<td>Problem-solving</td>
<td>fostered</td>
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<tr>
<td>Project Management</td>
<td>assessed</td>
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</table>

### Notes

- Slides and lecture notes will be made available at [http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html](http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html)

### Literature

- Extensive literature list distributed in course

### Prerequisites / notice

- 2 contact hours per lecture / week including lectures, exercises and practical study of samples, and small literature-based student presentations. Supplementary contact for sample practicals and exercises as required. Credits and mark based on participation in course (exercises, 50%) and 1h30 written exam in the last lecture of the semester (50%).
## Case Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>860-0011-00L</td>
<td>Complex Social Systems: Modeling Agents, Learning, and Games - With Coding Project</td>
<td>W</td>
<td>6 credits</td>
<td>2S+2A</td>
<td>D. N. Dailisian, D. Helbing, D. Carpentras</td>
</tr>
</tbody>
</table>

**Abstract**

This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research.

Students develop a significant project to tackle techno-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

**Objective**

The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

**Content**

Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

**Lecture notes**

The lecture slides will be presented on the course web page after each lecture.

**Literature**

Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization
https://www.i-spring.com/gp/book/9783642240034

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.

**Prerequisites / notice**

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td></td>
<td>Negotiation</td>
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<td>Personal Competencies</td>
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<td></td>
<td>Creative Thinking</td>
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### Transport Planning Methods

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>W</th>
<th>Credits</th>
<th>4G</th>
<th>E. Heinen</th>
</tr>
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<tr>
<td>101-0417-00L</td>
<td>Transport Planning Methods</td>
<td></td>
<td>6</td>
<td></td>
<td>E. Heinen</td>
</tr>
</tbody>
</table>

#### Abstract

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis.

#### Objective

- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve/answer planning problems
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

#### Content

- Getting familiar with cost-benefit analysis as a decision-making supporting tool.
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#### Literature


### Case Study Research Paper in Science, Technology and Policy

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<tr>
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<th>Credits</th>
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<th>Lecturers</th>
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<tr>
<td>860-0040-00L</td>
<td>Case Study Research Paper in Science, Technology and Policy 1</td>
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<td>Lecturers</td>
</tr>
<tr>
<td>860-0040-01L</td>
<td>Case Study Research Paper in Science, Technology and Policy 2</td>
<td></td>
<td>3</td>
<td></td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

#### Prerequisites / notice

Students are able to apply their problem-solving and analytical skills to address a particular societal challenge. Based on what they have learned, or are learning, in the companion course, and the skills and knowledge acquired in the social sciences courses of the ISTP curriculum, students identify a particular policy challenge to be addressed. Coached by the instructor of the companion course, or in exceptional cases by another ISTP professor, the develop and implement their research idea, according to the ISTP guidelines to this end. The result should be a research paper of around 4'000 words (all inclusive, except appendices) that will be graded by the supervisor on the 1-6 scale, based on a grading scheme for this purpose.

#### Objective

- Getting familiar with cost-benefit analysis as a decision-making supporting tool.
- Getting familiar with cost-benefit analysis as a decision-making supporting tool.
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- Getting familiar with cost-benefit analysis as a decision-making supporting tool.

#### Content

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- Getting familiar with cost-benefit analysis as a decision-making supporting tool.

#### Literature

Students can enroll in this unit exclusively in combination with another (companion) course to complete the Case Study requirements in the MSc ISTP. The unit allows students to carry out case studies on specific policy issues based on their individual preferences. The companion course should have a policy focus or deal with a policy relevant issue and can be taken either in parallel or prior to the Case Study Research Paper unit. The instructor of the companion course should be able and willing to also serve as the supervisor of the associated case study paper. In the case study research paper, students apply skills and knowledge acquired in the social sciences courses of the ISTP curriculum to address a particular societal challenge.

After successfully completing the companion course and the research paper, the student office will assign both courses to the category case studies.

851-0760-00L Building a Robot Judge: Data Science for Decision-Making

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a seminar paper, students (individually or in groups) will conceive and implement an applied data-science research project.

701-1563-00L Climate Policy

Abstract
This course provides an in-depth analysis of different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.

Objective
The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

Content
Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 20 to 30 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It’s a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law forbidding people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

Literature
There will be reading assignments for select classes. All of these will be posted in PDF format on a course Moodle. In addition, there will be one book and one report to be read over the course of the semester. They are:

- Ministry of the Future, by Kim Stanley Robinson

Competencies

- Ten Principles for Policy Making in the Energy Transition, by Laura Diaz Anadon et al.

Competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: fostered
  - Communication: fostered
  - Negotiation: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
History and Theory of Urban Design (Avermaete)

Does not take place this semester.
A student can only register once for a “Fachsemester”
during the Master studies!

The application deadline for this “Fachsemester” 4.9.2024,
8 p.m. You will receive a message about acceptance or
rejection for the subject semester by 5.9.2024, 2 p.m. at
the latest. Students who have been rejected have the
opportunity to choose a design class (enrollment ends on
5.9.2024, at 6 p.m.).

Abstract
This Research Studio focuses on the entanglements of the architectural and urban histories of Switzerland and the history of global colonialism. Through architecture-specific research methods, it investigates how centuries of colonialism have historically influenced the aesthetic, construction and craft cultures of Swiss cities, and explores ways to engage with these contested legacies today.

Objective
The Research Studio has two main objectives:

1. Archaeology of Swiss Coloniality.

First, students will develop an ‘archaeology’ of the historical entanglements of Swiss industry with global colonialism. In this part, the studio work is understood as an archaeological venture, digging up traces of the past. Students will systematically probe the built environment of Switzerland for traces and influences of global colonialism and its aftermath. The result will be a catalogue of colonial entanglements, illustrating how they are inscribed into architectural and urban figures and how they continue to impact the urban fabric of Switzerland and its industry.

2. Processing Swiss Coloniality.

In a second step, students will attempt to ‘process’ the enduring impact of Swiss Coloniality. Based on the ‘Archaeology,’ students will explore the inherent logics of global colonialism in relation to Swiss industry as it impacts the present. The central idea is to avoid considering the past as a closed chapter, but as an ongoing process and condition of coloniality that still structures our present and future, which needs acknowledgement and dialogue. Students will be asked, using the tools of the architect, to explore strategies to represent these entanglements and suggest openings for repair where needed.

Based on these main objectives, this course will:
- offer students an overview of the most important historical and contemporary contributions to debates on postcolonial and decolonial theory and the entanglement of Switzerland’s industry with global colonialism;
- equip students to reflect critically upon the manifestations of Swiss Coloniality in the built environment with the help of both theoretical and historical perspectives;
- make students aware that the production of the city is not a neutral given but is always shaped by cultural values, assumptions, and expectations, which impact the everyday environment and, as such, condition inhabitants and users;
- help students to position themselves within current debates on cities, urban development, and urban life in relation to broader challenges such as sustainability and social inequality.

Content
Swiss Coloniality

Cities have never been isolated entities and have always existed by grace of the myriad connections with their hinterland. Throughout the past centuries, and especially since the 15th century onwards, these connections have become increasingly far-reaching across the globe, and the history of urban development in areas such as Europe has been intricately entwined with conditions and realities elsewhere. As such, urban history cannot be seen as entirely separate from global colonialism and its aftermath. While designing and constructing the architecture of the city, architects, urban designers, builders, and inhabitants also inevitably take part in the wider ecologies of material and immaterial flows that are shaped by and contribute to a global system of inequality. Not uncoincidentally, the metropole – a key term of colonial history – finds its roots in the political urban figure of the polis and identifies the center-periphery relationship between the ‘motherland’ and its hinterland. The metropole is the place from where power is exercised over foreign territories and the place that reaps the fruits of this exercising of power.

While Switzerland never had colonies of its own, it was nevertheless in many ways involved in and contributed to the history of global colonialism: by taking part in the economy sustained by colonialism, by financing and securing slave trade, by contributing to race-based science practices, etc. So, despite being a country without colonies, what if we consider Switzerland and its position in the world from the perspective of the colonial metropole? What would be the specific architectural and urban dimension of this figure of Metropolis Switzerland? In raising such questions, in this Research Studio, we aim to focus on the entanglements of the architectural and urban histories of Switzerland and the history of global colonialism.

Starting to answer such questions requires a widened understanding of colonialism and its impact, which has been grasped with the notion of coloniality in recent debates. While colonialism refers to the historically specific phenomenon of one area of the world colonizing another, settling on foreign land, extracting its resources, and violently disciplining its inhabitants, the term coloniality refers to the more long-lasting processes and indirect effects that are the result of centuries of colonialism, and that mark a landscape of global inequality, even after the ‘official’ reign of colonialism has ended. In this sense, the disparity between the so-called ‘Global North’ and ‘Global South’, and the way in which a country such as Switzerland is still profiting from an advantageous position in this globally unequal world, can be considered the result of centuries of colonialism, and to be still part of a condition of coloniality. As this condition is a two-sided and mutually inflicting phenomenon, to unravel the knot of Swiss coloniality, we not only aim to investigate how Switzerland was implicated in activities abroad but also, conversely, how these activities have impacted Switzerland. While in the fields of political, social and economic history, a revisionist effort is underway to reconsider/correct the image of Switzerland as a neutral country without colonies, in the field of architecture and urban history, however, we are yet to unravel the impact of this entanglement on the built environment, and, more widely, on the aesthetic, material and craft cultures of Swiss cities.
The overarching hypothesis of this Research Studio is that historical and theoretical research can profit profoundly from the use of the tools and knowledge of architects. On the one hand, the spatial, formal, material, and constructive knowledge gained throughout architectural studies will guide the historical research in the archives, in the library, and/or in the city itself and will allow students to articulate specifically architectural interpretations of the materials they find. On the other hand, the Studio explicitly asks students to employ specific architectural tools such as drawing, writing and model-making to explore the historical and theoretical realities that are being investigated. By actively reflecting on the composition of a varied set of analytical and interpretative drawings, texts, and models, students will probe the capacity of these media to act as tools for historical and theoretical research.

Within the general theme of Swiss Coloniality, students will be guided to identify their own subtheme, which will require exploring their own specific research methodologies. These architecture-specific methodologies will be strategically chosen to discuss specific aspects of society: political, economic, social, cultural, or otherwise. Thus, conceiving these 'autonomous' and 'heteronomous' dimensions of architecture, a new understanding of the city and our built environment is developed that allows us to answer (some of) the research questions mentioned previously.

Research process

Students will be guided through three phases with different emphases: Definitions, Logics and Reinterpretations of Swiss Coloniality. The first phase, Definitions, is focused on developing an understanding of what the notion of Swiss Coloniality can entail and how it relates specifically to industry and the production of the city. This phase will allow students to become familiar with the historical and current entanglements of Switzerland with global colonialism and, by closely examining its main actors, practices, and materials, will set the stage for students to develop their own, individual research project.

The second phase, Logics, is about understanding and demonstrating the inner workings and mechanisms of Swiss Coloniality. Each of the students will focus on one specific case – a material, a site, an actor, a practice, etc. – and will examine it closely through targeted archival and library research, as well as through drawing, writing, and model-making.

In the third phase, Reinterpretations, students will formulate and investigate a hypothesis regarding the entanglements of Swiss industry with global colonialism. Based on this hypothesis, students will position themselves in relation to Swiss Coloniality, its history and its enduring impact. The position statement can take the form of a written text, architectural drawings and/or models and will be presented in the form of a student-curated studio exhibition and an online adaptation of it.

Further course information on https://avermaete.arch.ethz.ch/researchstudio

The Research Studio is self-dependent work and tutoring takes place on Tuesdays and Wednesdays.

Further course information on https://avermaete.arch.ethz.ch/researchstudio
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication

Personal Competencies
- Critical Thinking
- Self-direction and Self-management

**Objective**
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. Broaden understanding of management principles and frameworks
2. Advance insights into the sources of corporate and entrepreneurial success
3. Develop skills to apply knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and/or appreciate the challenges that entrepreneurs and managers deal with.

**Content**
The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

**Competencies**
- Concepts and Theories
- Analytical Competencies
- Communication
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

**851-0778-00L**

<table>
<thead>
<tr>
<th>Discovering Management</th>
<th>W</th>
<th>3 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Does not take place this semester.</em></td>
<td></td>
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</tr>
<tr>
<td>Entry level course in management for BSc, MSc and PhD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Exercises) 351-0778-01.</td>
<td></td>
<td></td>
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</tbody>
</table>

**Abstract**
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

**Objective**
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. Broaden understanding of management principles and frameworks
2. Advance insights into the sources of corporate and entrepreneurial success
3. Develop skills to apply knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and/or appreciate the challenges that entrepreneurs and managers deal with.

**Content**
The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

**Competencies**
- Concepts and Theories
- Analytical Competencies
- Communication
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

**851-0609-06L**

<table>
<thead>
<tr>
<th>Governing the Energy Transition</th>
<th>W</th>
<th>2 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Primarily suited for Master and PhD level.</em></td>
<td></td>
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</tbody>
</table>

**Abstract**
This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-economic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.

**Objective**
- To gain an overview of the history of the transition of large technical systems
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions
- To gain knowledge on the role of policy and politics in energy transitions

**Content**
Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary.

This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The grade will be determined by a final exam.

**Lecture notes**
Slides and reading material will be made available via moodle.ethz.ch (only for registered students).

**Literature**
A reading list will be provided via moodle.ethz.ch at the beginning of the semester.

**Prerequisites / notice**
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

**857-0027-00L**

<table>
<thead>
<tr>
<th>International Organizations (Field Trip)</th>
<th>W</th>
<th>2 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A two-day field trip to international organizations in Geneva - e.g., the World Trade Organization, the World Health Organization and the International Committee of the Red Cross.</em></td>
<td></td>
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</tbody>
</table>

**Abstract**
A two-day field trip to international organizations in Geneva - e.g., the World Trade Organization, the World Health Organization and the International Committee of the Red Cross.

**Objective**
Become familiar with the work and challenges of international organizations based in Geneva.
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined.

The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

The course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

Subjects Covered:
- international problem-solving efforts (cooperation)
- environmental politics
- international environmental politics
- social sciences viewpoint
- identifying interesting/innovative questions
- conceptually and methodologically meaningful and insightful way
- global and regional environmental problems
- international efforts to reduce air pollution
- managing international water resources
- mitigating and adapting to global warming
- protecting the stratospheric ozone layer
- addressing biodiversity challenges
- dealing with plastic waste
- preventing pollution of the oceans

Prerequisites:
- International Environmental Politics
- 860-0023-00L

Competencies:
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies, Problem-solving
- Personal Competencies: Creative Thinking, Critical Thinking

Literature:
## Competencies

### Subject-specific Competencies
- Concepts and Theories
- Decision-making
- Problem-solving
- Project Management

### Method-specific Competencies
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

### Social Competencies
- Problem-solving
- Project Management
- Communications
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### From Traffic Modeling to Smart Cities and Digital Democracies

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit</th>
<th>Start</th>
<th>End</th>
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<tbody>
<tr>
<td>851-0467-00L</td>
<td>From Traffic Modeling to Smart Cities and Digital Democracies</td>
<td>3</td>
<td>2S</td>
<td>D. Helbing, R. K. Dubey</td>
</tr>
</tbody>
</table>

### Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution.

### Objective
To collect credit points, students must actively contribute and give an individual, circa 20-minute presentation in the seminar on a subject agreed upon with the lecturer. After the presentation, it will be discussed and graded.

### Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.

### Literature
- Dirk Helbing
  - An Analytical Theory of Traffic Flow (collection of papers)
- Michael Batty, Kay Axhausen et al.
  - Smart cities of the future
- Books by Michael Batty:
  - How social influence can undermine the wisdom of crowd effect
  - Evidence for a collective intelligence factor in the performance of human groups
  - Optimal incentives for collective intelligence
  - Collective Intelligence: Creating a Prosperous World at Peace
  - Big Mind: How Collective Intelligence Can Change Our World
  - Programming Collective Intelligence
  - Urban architecture as connective-collective intelligence. Which spaces of interaction?
  - Build digital democracy
  - How to make democracy work in the digital age
  - Digital Democracy: How to make it work?
  - Proof of witness presence: Blockchain consensus for augmented democracy in smart cities
  - Iterative Learning Control for Multi-agent Systems Coordination
  - Decentralized Collective Learning for Self-managed Sharing Economies
  - Students need to present a new subject, for which they have not earned any credit points before.
  - Good scientific practices, in particular citation and quotation rules, must be properly complied with.
  - Chatham House rules apply to this course. Materials may not be shared without previous written permission.
### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<td></td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Negotiation</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</tbody>
</table>

### Computational Social Science  ■

<table>
<thead>
<tr>
<th>851-0585-41L</th>
<th>W 3 credits</th>
<th>2S</th>
<th>D. Helbing, C. I. Hausladen, J. C.-Y. Yang</th>
</tr>
</thead>
</table>

### Abstract

The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g. sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work.

### Objective

Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

Computational Social Science and Global Systems Science serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e. an interdisciplinary integration of knowledge.

### Literature

- Ball: Why Society Is A Complex Matter
- Helbing: Social Self-Organization
- Helbing: Managing Complexity
- Colander/Kupers: Complexity and the Art of Public Policy
- Mitchell: Complexity
- Buckley: Society – A Complex Adaptive System
- Castellani/Hafferty: Sociology and Complexity Science
- Mikhailov/Calenbuhr: From Cells to Society
- Mainzer: Thinking in Complexity
- Sawyer: Social Emergence
- Books published by the Santa Fe Institute

### Prerequisites / notice

- Students need to present a new subject, for which they have not earned any credit points before.
- Further literature will be recommended in the lectures.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
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<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td>Project Management</td>
<td>Negotiation</td>
<td></td>
<td>Self-awareness and Self-reflection</td>
</tr>
</tbody>
</table>

**Abstract**

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

**Objective**

- Students are introduced to a narrative of ‘Urban Stories’ through a series of three tools driven by social, governance, and environmental transformatons in today's urbanization processes. Each lecture explores one city's spatial and organizational ingenuity born out of a particular place's realities, allowing students to transfer these inventions into a catalog of conceptual tools.
- How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design instruments to the students to use, test, and start their designs.

**Content**

- Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.
- The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

**Literature**


**Competencies**

<table>
<thead>
<tr>
<th>363-0537-00L Resource and Environmental Economics</th>
<th>363-0537-00L Urban Design III</th>
</tr>
</thead>
<tbody>
<tr>
<td>W 3 credits</td>
<td>W 2 credits</td>
</tr>
<tr>
<td>2G</td>
<td>F. T. Salva Rocha Franco</td>
</tr>
<tr>
<td>A. Miftakhova, A. Minabutdinov</td>
<td>H. Klumpner</td>
</tr>
</tbody>
</table>

**Abstract**

Students are introduced to a narrative of ‘Urban Stories’ through a series of three tools driven by social, governance, and environmental transformations in today's urbanization processes. Each lecture explores one city's spatial and organizational ingenuity born out of a particular place's realities, allowing students to transfer these inventions into a catalog of conceptual tools.

**Objective**

- How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Govercmen, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Design is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2288 of 2667
Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

### Lecture notes

The learning material, available via [https://moodle-app2.let.ethz.ch/](https://moodle-app2.let.ethz.ch/) is comprised of:

- Toolbox 'Reader' with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings
- Reading material will be provided throughout the semester.

### Literature

**851-0101-86L Complex Social Systems: Modeling Agents, Learning, W**

Prerequisites: Basic programming skills, elementary probability and statistics.

**Abstract**

This course introduces mathematical and computational models to study techno-socioeconomic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and to communicate their results through a project report and a short oral presentation.

**Objective**

See your own field of study in a wider context (“Science in Perspective”), e.g. see the psychological, social, economic, environmental, historical, ethical, or philosophical connections and implications. Learn to think critically and out of the box. Question what you believe you know for sure. Get to know surprising, counterintuitive properties of complex (non-linearly interacting, networked, multi-component) systems. Learn about collaboration.

**Content**

By the end of the course, the students should be able to better understand the literature on complex social systems, develop their own models for studying specific phenomena and report results according to the standards of the relevant scientific literature by presenting their results both numerically and graphically.

At the end of the course, the students will deliver a report, computer code and a short oral presentation. To collect credit points, students will have to actively contribute and give a circa 30 minutes presentation in the course on a subject agreed with the lecturers, after which the presentation will be discussed. The presentation will be graded.

Students are expected to implement themselves models of techno-socio-economic processes and systems, particularly agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature, its presentation, and documentation by a project report.

**Lecture notes**

The lecture slides will be presented on the course Moodle after each lecture.

**Literature**

Agent-Based Modeling

[https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2](https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2)

Social Self-Organization


Traffic and related self-driven many-particle systems

Reviews of Modern Physics 73, 1067


An Analytical Theory of Traffic Flow (collection of papers)

[https://www.researchgate.net/publication/261629187](https://www.researchgate.net/publication/261629187)

Pedestrian, Crowd, and Evacuation Dynamics


The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)

[https://science.sciencemag.org/content/342/6164/1337](https://science.sciencemag.org/content/342/6164/1337)
Prerequisites / notice

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Competencies

- **Subject-specific Competencies**
  - Concepts and Theories assessed
  - Techniques and Technologies assessed

- **Method-specific Competencies**
  - Analytical Competencies assessed
  - Decision-making assessed
  - Media and Digital Technologies fostered
  - Problem-solving assessed
  - Project Management assessed

- **Social Competencies**
  - Communication assessed
  - Cooperation and Teamwork assessed
  - Customer Orientation fostered
  - Leadership and Responsibility assessed
  - Self-presentation and Social Influence assessed
  - Sensitivity to Diversity assessed
  - Negotiation fostered

- **Personal Competencies**
  - Adaptability and Flexibility assessed
  - Creative Thinking assessed
  - Critical Thinking assessed
  - Integrity and Work Ethics assessed
  - Self-awareness and Self-reflection assessed
  - Self-direction and Self-management assessed

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Prerequisites / notice

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Law & Tech (851-0732-06L, HS 2024)" and enroll.

Competencies

- **Subject-specific Competencies**
  - Concepts and Theories assessed

- **Method-specific Competencies**
  - Analytical Competencies assessed
  - Media and Digital Technologies assessed

- **Social Competencies**
  - Communication assessed

- **Personal Competencies**
  - Creative Thinking assessed
  - Critical Thinking assessed

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Prerequisites / notice

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "International Engineering (151-8101-00L, HS 2024)" and enroll.

Competencies

- **Subject-specific Competencies**
  - Concepts and Theories assessed

- **Method-specific Competencies**
  - Analytical Competencies assessed
  - Media and Digital Technologies assessed

- **Social Competencies**
  - Communication assessed

- **Personal Competencies**
  - Creative Thinking assessed
  - Critical Thinking assessed
This lecture series explores the multifaceted role of data in shaping contemporary society, governance, and individual lives. The course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to examine the complex role that well-meaning foreigners have played and continue to play in the disappointing health outcomes that characterize much of the African continent.

After completing the course, participants will be able to:
- critique the jargon and terms used by the international community, i.e. “development”, “aid”, “cooperation”, “assistance” “third world” “developing” “global south” “low and middle-income” and justify their own chosen terminology
- recognize the role of racism and white-supremacy in the development of the Aid industry
- understand the political, financial, and cultural reasons why technology and infrastructure have historically failed
- Debate the merits of international engineering in popular culture and media
- Propose improved SDG indicators that address current shortcomings
- Compare the engineering curricula of different countries to identify relative strengths and shortcomings
- Explain the inherent biases of academic publishing and its impact on engineering failure
- Analyse linkages between the rise of philanthropy and strategic priority areas
- Recommend equitable, just funding models to achieve more sustainable outcomes
- Formulate a vision for the international engineer of the future

Content
- Role of international engineering during colonialism
- Transition of international engineering following colonialism
- White saviourism and racism in international engineering
- International engineering in popular culture
- The missing role of Engineering Education
- Biases in academic publishing
- The emerging role in Global Philanthropy
- The paradox of international funding

Literature

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

Objective
- Building a Robot Judge: Data Science for Decision-Making
  - W 3 credits 2V E. Ash
  - Does not take place this semester.
  - Particularly suitable for students of D-INFK, D-ITET, D-MTEC.

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

Objective
- Data and Society
  - W 3 credits 2V M. Leese
  - This lecture series explores the multifaceted role of data in shaping contemporary society, governance, and individual lives. The course equips students with a critical understanding of how data is made, managed, and preserved, and its implications for societal norms and individual rights.

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
At the end of the term, students will be able to:
- reflect concepts and theories that capture the performativity of data
- reflect concepts and theories that capture the socio-technical nature of data
- assess the implications of data practices for social and political ordering
- identify key actors, sites, and domain contexts of data practices
## Internship

The performance counts as electives.

### Number | Title | Type | ECTS | Hours | Lecturers |
--- | --- | --- | --- | --- | --- |
860-0600-00L | Internship - Short | W | 6 credits | external organisers |
860-0700-00L | Internship - Long | W | 12 credits | external organisers |

### Master’s Thesis

### Number | Title | Type | ECTS | Hours | Lecturers |
--- | --- | --- | --- | --- | --- |
860-0900-00L | Master’s Thesis | O | 30 credits | 64D | Professors |

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>W</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W+</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
<td>Key for Hours</td>
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<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
The main goal of the course is to give the students an overview of physical phenomena that lead to impacts on the Earth and our technical infrastructure. The physics of solar flares, coronal mass ejections and the solar wind and how they are triggered and transport through the solar system is covered. The lectures introduce the basics of the terrestrial and giant planets, comets, and asteroids, gained from modern space missions and the study of extraterrestrial material from both the physical and geochemical perspectives. Students will practice making quantitative calculations relevant to various aspects of these topics through homework.

### Scientific Introductory Courses

Students must complete at least two out of the three scientific introductory courses to reach a minimum of 8 credits.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-7011-00L</td>
<td>Introduction to Planetary Science</td>
<td>W+</td>
<td>4</td>
<td>2G</td>
<td>M. Schönbächler, H. Busemann, M. Ek, C. Gillmann, A. Mittelholz</td>
</tr>
</tbody>
</table>

#### Abstract

This course aims to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:

1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

#### Objective

The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students must complete at least two out of the three scientific introductory courses to reach a minimum of 8 credits.

#### Content

- Einführung in die Techniken und Methoden zur Bestimmung von Umweltparametern
- Einführung in die Verfahren zur Bestimmung von Umweltparametern in der Hydrologie, Glaziologie, Forst und Landwirtschaft, Geologie und Topographie

#### Competencies

- Subject-specific Competencies
- Concepts and Theories

#### Literature

Folienset zu jedem Vorlesungsblock werden zur Verfügung gestellt.

### Deep Track Courses

At least 20 credits must be completed within the deep track courses. Surplus credit points can be counted towards the electives.

#### Aerospace Engineering

These courses can be credited either as a specialization subject or as an elective subject.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0187-02L</td>
<td>Satellite Geodesy</td>
<td>W+</td>
<td>4</td>
<td>3G</td>
<td>M. Alchinger-Rosenberger</td>
</tr>
</tbody>
</table>

#### Abstract


#### Objective

- Sicherheit im Umgang mit Koordinaten-, Referenz- und Zeitsystemen
- Grundlegendes Verständnis der Berechnung von Satellitenbahnen
- Grundlegendes Verständnis der geodätischen Weltraumverfahren und deren Stärken und Schwächen
- Kenntnis der wichtigsten Prozesse, die für Änderungen in der Geometrie, der Rotation und dem Schwerefeld der Erde verantwortlich sind.
- Erkennen der Anwendungsmöglichkeiten der Satellitengeodäsie für interdisziplinäre Aufgaben (System Erde).

#### Content

- Koordinatensysteme, Transformationen
- Referenz- und Zeitsysteme
- Grundlagen Satellitenbahnen
- Weltraumverfahren: VLBI, SLR, DORIS, Altimetrie
- Schwerefeldmissionen
- Kombination der Weltraumverfahren zur Bestimmung der Geometrie, Orientierung sowie des Schwerefeldes der Erde
- Interdisziplinäre Anwendungen (Meteorologie, Klimatologie, Hydrologie, etc.)
Introduction to Dynamic Programming and Optimal Control.

- Properties of laminar, transitional and turbulent flows.
- Introduction to Aircraft and Car Aerodynamics

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving
- Communication
- Cooperation and Teamwork
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection

**Prerequisites / notice**

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

**Literature**

- F. Ernst, C. E. Frouzakis, "Fostered Introduction to Dynamic Programming and Optimal Control.

**Course Description**

This course will provide an introduction to the fundamentals and applications of combustion in energy conversion and nanoparticles synthesis. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

**Literature**


**Course Content**

- Laminar and turbulent flows, instability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scalings, Homogeneous isotropic turbulence, correlations, Fourier representation, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows
- Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling
- Properties of laminar, transitional and turbulent flows.
- Origin and control of turbulence. Instability and transition.
- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.
- Scalings, homogeneous isotropic turbulence, energy spectrum.
- Turbulent free shear flows. Jet, wake, mixing layer.
- Wall-bounded turbulent flows.
- Turbulent flow computation and modeling.

**Lecture notes**

Lecture notes are available

**Additional Information**

- The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

- Reaction kinetics, fuel oxidation mechanisms, premixed and diffusion laminar flames, two-phase-flows, turbulence and turbulent combustion, pollutant formation, development of sustainable combustion technologies for power generation, shipping and aviation.

Embedded Systems

An embedded system is a combination of hardware and software, either fixed in function or programmable, that is designed for a specific application scenario or for a specific task within a larger system. They are part of industrial machines such as agricultural and manufacturing equipment, automotive systems, medical equipment, household appliances, sensor networks, and the Internet of Things.

Objective

Understanding the specific requirements and problems that arise in embedded system applications.

Using formal models and methods for designing and optimizing embedded systems.

Gaining experience with practical applications of the C programming language, embedded real-time operating systems, and debug functionalities of the associated design environment to design, implement, and verify embedded firmware.

Through project-based activities, students will gain substantial experience in applying the C programming language in the context of embedded systems. Projects will involve developing and implementing firmware, utilizing embedded real-time operating systems, and exploring the debugging functionalities within design environments. This hands-on approach aims to bridge the gap between theoretical knowledge and practical application, allowing students to experience the full lifecycle of embedded system development from design to implementation and verification.

Content

This lecture focuses on the design of embedded systems using formal models and methods.

Besides the theoretical lecture, the course contains laboratory sessions where students transfer the learned theoretical aspects into praxis by programming a microcontroller and interfacing it with sensors and actuators. Students will be exposed to a commercial microcontroller, and the development board extend with a custom-designed embedded systems educational platform.

Specifically, the following topics will be covered in the course: hardware and software structures of embedded systems, low-level instruction set, memory architecture and memory map, peripherals, hardware-software interfaces, communication between components, firmware design methodologies, firmware design using the C programming language, embedded real-time operating systems, real-time scheduling, shared resources, low-power, and low-energy designs as well as computational accelerators.

Lecture notes

Lecture material, publications, exercise sheets, and laboratory documentation will be available on the course's Moodle page.

Literature


Prerequisites / notice

Prerequisites: C programming, circuit theory, digital logic, binary number representations.

Competencies

Subject-specific Competencies

| Concepts and Theories | assessed |
| Techniques and Technologies | assessed |

Elective Courses Aerospace Engineering

These subjects can only be credited as electives.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>103-0187-01L</td>
<td>Space Geodesy</td>
<td>W+</td>
<td>6</td>
<td>4G</td>
<td>B. Soja</td>
</tr>
</tbody>
</table>

Abstract


Objective

After this course, the students should be able to

- Describe the major observation techniques in space geodesy
- Describe the necessary modeling and analysis approaches to derive geodetic products of highest quality
- Select the appropriate space geodetic data for scientific investigations
- Analyze the space geodetic data for scientific purposes
- Interpret the scientific results

Content

Overview of GNSS, Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments and observation equations.

Modelling of the station motions and the estimation of station coordinates. Basics of wave propagation in the atmosphere. Signal propagation in the ionosphere and troposphere for the different observation techniques and the determination of atmospheric parameters.

Equation of motion of the unperturbed and perturbed satellite orbit. Osculating and mean orbital elements. General and special perturbation theory and the determination of satellite orbits.

Lecture notes

Script M. Rothacher "Space Geodesy"
The course will provide a basic physical understanding of flow-structure interaction focused on lifting bodies such as wings. You will get to understand the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Abstract

Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective

Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content

Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Lecture notes

Comprehensive copy of transparencies

Literature


Competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies

Communication
Cooperation and Teamwork

Personal Competencies

Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-direction and Self-management

227-0377-10L Physics of Failure and Reliability of Electronic Devices and Systems W+ 3 credits 2V I. Shorubalko, M. Held

151-0368-00L Aerelasticity W+ 4 credits 2V+1U M. Righi

Abstract

Introduction to the basics and into the methods of Aerelasticity. An overview of the main static and dynamic phenomena arising from the interaction between structural and aerodynamic loads.

Objective

The course will provide a basic physical understanding of flow-structure interaction focused on lifting bodies such as wings. You will get to know the most important phenomena in the static and dynamic aerelasticity, as well as a presentation of the most relevant analytical and numerical prediction methods.

Content

Introduction to steady and unsteady thin airfoil theory, extension to three dimension wing aerodynamics, strip theory, overview of numerical methods available (panel methods, CFD).

Introduction to unsteady aerodynamics (theory): Theodorsen and Wagner functions. Unsteady aerodynamics observed from numerical experiments (CFD). Generation of simplified mathematical models.

Presentation of steady aerelasticity: equations of equilibrium for the typical section, aeroelastic deformation, effectiveness of the aeroelastic system, stability (definition), divergence condition, role played by a control surface, control effectiveness, sweep angle, aerelastic tailoring of bending-torsion coupling. Ritz model to model beams, use of FEM, modal condensation, choice of generalized coordinates.


Numerical aerelasticity (Test Cases extracted from the latest AIAA Aeroelastic Prediction Workshops). Generation of Reduced Order Models from CFD data (in some cases though Machine Learning).

Aerelasticity of modern aircraft: assessment of the effects induced by the control surfaces and control systems (Aeroservoelasticity), active controlled aircraft, flutter-suppression systems, certification (EASA, FAA).

Planning and execution of Wind Tunnel experiments with aeroelastic models. Live-execution of an experiment in the WT of the ETH.

Brief presentation of phenomena like Limit-Cycle Oscillations (LCO) and panel flutter.

Lecture notes

A script in English language is available.

Literature

Bispelnhoff Ashley, Aerelasticity
Abbott, Theory of Wing sections,

151-0532-00L Nonlinear Dynamics and Chaos I W+ 4 credits 4G G. Haller

Abstract

Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective

This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.
The course builds upon three parts:

1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

151-0215-00L Fundamentals of Acoustics

Abstract
This course provides an introduction to acoustics. It focuses on fundamental phenomena of airborne and structure-borne sound waves. The lecture combines theoretical principles with practical insights and interpretations.

Objective
This course is proposed for Master and PhD students interested in getting knowledge in acoustics. Students will be able to understand, describe analytically and interpret sound generation, absorption and propagation.

Content
First, magnitudes characterizing sound propagation are reviewed and the constitutive equations for acoustics are derived. Then the different types of sources (monopole/dipole/quadrupole, punctual, non-compact) are introduced and linked to the noise generated by turbulent flows, coherent vortical structures or fluctuating heat release. The scattering of sound by rigid bodies is given in basic configurations. Analytical, experimental and numerical methods used to analyze sound in ducts and rooms are presented (Green functions, Galerkin expansions, Helmholtz solvers).

The second part covers elastic wave phenomena, such as dispersion and vibration modes, in infinite and finite structures.

Lecture notes
Handouts will be distributed during the class.

Literature
Books will be recommended for each chapter.

151-0213-00L Fluid Dynamics with the Lattice Boltzmann Method

Abstract
The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Objective
Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.

Content
The course builds upon three parts:
I. Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II. Theoretical basis of statistical mechanics and kinetic equations.
III. Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation; 
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.
2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.
3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).
4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.
5. Microflow:
   Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.
6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.
7. Introduction to LB models beyond hydrodynamics:
   Relativistic fluid dynamics; flows with phase transitions.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available. Selected original and review papers are provided for some of the lectures on advanced topics. Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice
The course addresses mainly graduate students (MSc/PhD) but BSc students can also attend.
Space Communication

These courses can be credited either as a specialization subject or as an elective subject.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0121-00L</td>
<td>Communication Systems</td>
<td>W+</td>
<td>6</td>
<td>4G</td>
<td>C. Studer, S. M. Moser</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course teaches the fundamentals of digital communication systems. The main topics are analog and digital modulation, signals and linear time-invariant systems, baseband and passband representations, continuous-time and discrete-time channels, noise, inter-symbol interference, detection theory, as well as the basics of forward error correction and information theory.</td>
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<tr>
<td>Objective</td>
<td>After attending the lectures, participating in the exercise sessions, and working on the homework problems (which include MATLAB coding assignments), the students will be able to:</td>
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<tr>
<td></td>
<td>- understand the fundamentals of digital communication systems</td>
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<td>- explain the principles of modulation, demodulation, detection, and error correction</td>
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<td></td>
<td>- analyze error rates of simple digital communication systems</td>
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<td></td>
<td>- implement simple MATLAB simulations to calculate error rates</td>
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<tr>
<td>Content</td>
<td>The course focuses on the fundamentals of digital communication systems. The course starts with analog modulation and discusses the main building blocks of modern digital communication systems. The topics include:</td>
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<tr>
<td></td>
<td>- essential components of digital communication systems</td>
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<tr>
<td></td>
<td>- analog and digital modulation</td>
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<td></td>
<td>- baseband and passband representation; up- and down-conversion</td>
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<td></td>
<td>- communication channels as LTI systems</td>
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<td>- discretizing communication systems; sampling and quantization</td>
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<td>- noise, signal-to-noise ratio (SNR), and interference</td>
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<tr>
<td></td>
<td>- detection theory and error rates</td>
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<td></td>
<td>- basics of forward error correction</td>
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<td>- basics of information theory</td>
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<td></td>
<td>- orthogonal frequency-division multiplexing (OFDM)</td>
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<td></td>
<td>- building blocks of modern communication systems</td>
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<tr>
<td>Lecture notes</td>
<td>The exercises cover theoretical aspects as well as the basics of software-based communication-system modeling in MATLAB.</td>
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<tr>
<td>Literature</td>
<td>Lecture notes will be distributed electronically at the beginning of the semester.</td>
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<td>Competencies</td>
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<td></td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td></td>
<td>Problem-solving</td>
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<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<tr>
<td>227-0301-00L</td>
<td>Optical Communication Fundamentals</td>
<td>W+</td>
<td>6</td>
<td>2V+1U+1P</td>
<td>J. Leuthold</td>
</tr>
<tr>
<td>Abstract</td>
<td>The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.</td>
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<tr>
<td>Objective</td>
<td>An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.</td>
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<tr>
<td>Content</td>
<td>* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.</td>
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<td></td>
<td>* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.</td>
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<td>* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.</td>
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<td>* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.</td>
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<td></td>
<td>* Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes are handed out.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Fundamentals of Electromagnetic Fields &amp; Bachelor Lectures on Physics.</td>
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<tr>
<td>227-0443-00L</td>
<td>Space Communications</td>
<td>W+</td>
<td>4</td>
<td>2V+2U</td>
<td>J. Smajic, M. Burla, J. Leuthold, R. Muff, C. Studer, H. Wang</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course has the following main goals: (a) to give a comprehensive overview of challenges on communication equipment imposed by space flight missions, (b) to present the theoretical fundamentals and existing practical solutions of communication technology for space missions, and (c) to review existing and future communication technologies for inter-satellite links, inter-spacecraft links, as well as technologies capable of enabling ultra-fast RF/mm-Wave, THz, and Laser communication links.</td>
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<tr>
<td>Objective</td>
<td>After completing this course, a student will understand the challenges of space flight imposed on communication components and systems, the available existing solutions of those problems, the main components of communications systems suitable for a spacecraft, and future technologies capable of enabling ultra-fast RF/mm-Wave, THz, and Laser communication links.</td>
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</table>
Lecturers fostered W

Data Conversion System Design

4 hours Analytical Competencies

Type
Introduction: examples of data conversion architectures; information representation; abstraction, categorization and symbolic
Space missions: scenarios and challenges on flight equipment

T. Burger
A. Lapidoth

Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema
This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over

https://search.library.ethz.ch/permalink/t1545k0d/e8b01_prodo0470125
Netherlands: Itpak print. https://doi.org/10.3990/1.978903657295
(TUP) https://doi.org/10.3990/1.9789036528603

Prerequisites / notice
Bachelor Studies of Electrical Engineering or Physics.

Elective Courses Space Communication

These subjects can only be credited as electives.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0417-00L</td>
<td>Information Theory I</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>A. Lapidoth</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equipartition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.</td>
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<tr>
<td>Objective</td>
<td>The fundamentals of Information Theory including Shannon's source coding and channel coding theorems</td>
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<tr>
<td>Content</td>
<td>The entropy rate of a source, Typical sequences, the asymptotic equipartition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity</td>
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<tr>
<td>Literature</td>
<td>T.M. Cover and J. Thomas, Elements of Information Theory (second edition)</td>
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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>227-0146-00L</td>
<td>Data Conversion System Design</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>T. Burger, G. Cervelli, R. Reutemann</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.</td>
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<tr>
<td>Objective</td>
<td>Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. Students will learn the underlying principles of data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or algorithmic conversion are explained based on their operation principle accompanied with the appropriate mathematical calculations, including effects of non-idealities in some cases. After successful completion of the course students should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.</td>
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<tr>
<td>Content</td>
<td>Introduction: examples of data conversion architectures; information representation; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; trade-offs among key parameters; ADC taxonomy.</td>
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<td>- Dual-slope &amp; successive approximation register (SAR) converters: dual slope principle &amp; converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.</td>
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<tr>
<td>- Algorithmic &amp; pipelined A/D converters: algorithmic conversion principle; sample &amp; hold stage; pipelined converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.</td>
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<tr>
<td>- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.</td>
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<td>- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkle correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters; cascaded folding and interpolation.</td>
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<td>- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.</td>
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<tr>
<td>- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-order delta-sigma modulation, circuit level implementation; clock-jitter &amp; SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.</td>
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<tr>
<td>Literature</td>
<td>Slides are available online under <a href="https://is-students.ee.ethz.ch/lectures/analog-to-digital-converters/">https://is-students.ee.ethz.ch/lectures/analog-to-digital-converters/</a></td>
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<tr>
<td>- M. Gustavsson et. al., CMOS Data Converters for Communications, Springer, 2010</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This highly recommended to attend the course &quot;Analog Integrated Circuits&quot; of Prof. T. Jang as a preparation for this course.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<tr>
<td>- Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>F. K. Gürcaynak</td>
</tr>
<tr>
<td>Abstract</td>
<td>This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.</td>
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<tr>
<td>Literature</td>
<td>Lecture notes, Matlab programs, exercises and their solutions will be handed out.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Bachelor Studies of Electrical Engineering or Physics.</td>
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</table>
Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes
Textbook and all further documents in English.

Literature

Prerequisites / notice
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://is-students.ee.ethz.ch/lectures/vlsi-i/

252-1411-00L Security of Wireless Networks W 6 credits 2V+1U+2A S. Capkun, K. Kostiainen
Objective
Understanding security aspects of wireless communication and a wide range of security-related topics in the domains of wireless technologies. The course mainly targets computer science students. Though useful, a background in signal processing or physical layer concepts is not required. A basic understanding of security (e.g. as taught in 252-0211.00L Information Security) is recommended.

Content
- Introduction to wireless communication
- Physical layer security schemes
- Spreading techniques and their application in jamming-resistant communication
- Global Navigation Satellite Systems (GNSSs)
- Secure ranging with Ultra-Wide Band (UWB)
- Security aspects of cellular networks, WiFi, and Bluetooth Low Energy (BLE)

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Problem-solving

Method-specificCompetencies
Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Critical Thinking

402-0448-01L Quantum Information Processing I: Concepts W 5 credits 2V+1U J. Renes
Objective
This course introduces the key concepts and fundamental formalism of quantum information processing. Topics include quantum algorithms, quantum error correction, quantum cryptography, and quantum metrology, with an emphasis on the power of quantum information processing beyond that of classical information processing. The formalism of quantum states, measurements, and channels is developed in detail.

Content
- The end of the course students are able to explain the basic mathematical formalism of quantum mechanics and apply it to quantum information processing problems. They are able to adapt and apply these concepts and methods to analyze and discuss quantum algorithms and other quantum information-processing protocols.

Prerequisites / notice
A good understanding of finite dimensional linear algebra is recommended.

References:

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2301 of 2667
Earth Observation

Deep Track and Elective Courses Earth Observation

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>102-0627-00L</td>
<td><strong>Applied Radar Remote Sensing</strong> 102-0617-01L</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>O. Frey</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides an introduction to processing and interpreting radar and synthetic aperture radar (SAR) remote sensing data. The primary topics of the course are interferometric techniques and related applications such as topography mapping and mapping of surface displacements, with a strong emphasis on solving practical problems using MATLAB. Objectives Understand the concepts and techniques required to process and to adequately interpret interferometric radar/SAR data for topographic mapping and surface displacement applications. Content The rationale behind the structure of the course follows the idea that radar imaging and radar/SAR interferometry are closely related and that a basic understanding of the radar imaging concept is helpful to understand and interpret interferometric radar data for various applications. The course starts with the real-aperture radar case and a first introduction to the concept of radar interferometry with applications to topographic mapping and mapping of surface displacements. Based on that, the 2-D imaging concept used in synthetic aperture radar imaging is treated. Then, we expand further on radar and SAR interferometric (InSAR) concepts and processing steps for single interferograms and stacks of interferograms also using persistent scatterer interferometry (PSI) to measure deformation based on time series of interferometric SAR data. Finally, the 3-D radar imaging case (SAR tomography) is put into context with PSI/InSAR time series as an extension of the more classical interferometric approaches thereby closing the circle around the strongly related concepts of SAR imaging and interferometry.</td>
<td>Lecture notes</td>
<td>Lecture notes/handouts for each topic will be provided online. Literature</td>
<td>Additional reading material: Hanssen, R. F., Radar interferometry: data interpretation and error analysis, Kluwer Academic Publishers, 2001. ISBN: 978-0-306-47633-4 <a href="https://doi.org/10.1007/0-306-47633-9">https://doi.org/10.1007/0-306-47633-9</a> Prerequisites / notice</td>
<td>It is highly recommended that the student has previously taken the following courses: 102-0617-00L: Basics and Principles of Radar Remote Sensing and 102-0617-01L: Methodologies for Image Processing of Remote Sensing Data</td>
</tr>
<tr>
<td>102-0617-00L</td>
<td><strong>Basics and Principles of Radar Remote Sensing</strong> for Environmental Applications</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>I. Hajnsek</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation. Objective</td>
<td>The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation. At the end of the course the student has the understanding of 1. SAR basics and principles, 2. SAR polarimetry, 3. SAR interferometry and 4. environmental parameter estimation from multi-parametric SAR data Content</td>
<td>The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following: 1. Introduction into SAR basics and principles 2. Introduction into electromagnetic wave theory 3. Introduction into scattering theory and decomposition techniques 4. Introduction into SAR interferometry 5. Introduction into polarimetric SAR interferometry 6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.) Lecture notes</td>
<td>Handouts for each topic will be provided. Literature</td>
<td>First readings for the course: Woodhouse, I. H., Introduction into Microwave Remote Sensing, CRC Press, Taylor &amp; Francis Group, 2006. Lee, J.-S., Potluri, E., Polarimetric Radar Imaging: From Basics to Applications, CRC Press, Taylor &amp; Francis Group, 2009. Complete literature listing will be provided during the course.</td>
</tr>
<tr>
<td>103-0187-01L</td>
<td><strong>Space Geodesy</strong></td>
<td>W+</td>
<td>6 credits</td>
<td>4G</td>
<td>B. Soja</td>
</tr>
<tr>
<td>Abstract</td>
<td>GNSS, VLBI, SLR/LLR and satellite altimetry: Principles, instrumentation and observation equation. Modelling and estimation of station coordinates and station motion. Ionospheric and tropospheric refraction and estimation and assessment of atmospheric parameters. Equation of motion of the unperturbed and perturbed satellite orbit. Perturbation theory and orbit determination. Objective</td>
<td>After this course, the student should be able to • Describe the major observation techniques in space geodesy • Describe the necessary modeling and analysis approaches to derive geodetic products of highest quality • Select the appropriate space geodetic data for scientific investigations • Analyze the space geodetic data for scientific purposes • Interpret the scientific results</td>
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</table>
For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, image retrieval, event-based vision, and visual-inertial odometry (the algorithms behind Hololens, Oculus Quest, and the NASA Mars rovers).

By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.

Theoretical Astrophysics (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: AST512

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract

This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Content

This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

Lecture notes

Script M. Rothacher “Space Geodesy”

Prerequisites / notice

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract

For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, image retrieval, event-based vision, and visual-inertial odometry (the algorithms behind Hololens, Oculus Quest, and the NASA Mars rovers).

Objective

Learn the fundamental computer vision algorithms used in mobile robotics, in particular: filtering, feature extraction, structure from motion, multiple view geometry, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry and Simultaneous Localization And Mapping (SLAM) (the algorithms behind Hololens, Facebook-Oculus Quest, and the NASA Mars rovers).

Content

Each lecture will be followed by a lab session where you will learn to implement a building block of a visual odometry algorithm in Matlab.

By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.

Lecture notes

Lecture slides will be made available on the course official website: http://rpg.ifi.uzh.ch/teaching.html

Literature


Note: If you are interested in taking UZH courses, you must register as an incoming mobility student at UZH. For details, see as follows:

UZH course enrollment for ETH student at University of Zurich (UZH) > Mobility within Switzerland – Incoming > Module Mobility: The easiest way to take individual modules/courses to supplement your studies at your home university is with module mobility. This option is not available to students who have dropped out of their home university or have been definitely excluded or banned from the relevant a program > Application and Deadlines: Applications are submitted via the UZH application portal (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html)

Step-by-step guidelines on how ETH students can register for this course, are given on the official course website: https://rpg.ifi.uzh.ch/teaching.html

ATTENTION: When you book the course at UZH, you are automatically registered for the exam at UZH and you can unregister until the October deadline. After registering for the course, you as an ETH student need to check out your **UZH email account** to receive the related information from the lecturer.
Literature

Course Materials:
1. The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
2. The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
3. Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
4. Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
5. Galactic Dynamics, James Binney and Scott Tremaine

Prerequisites / notice

This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

Prerequisites:
Introduction to Astrophysics
Mathematical Methods for the Physicist
Quantum Mechanics
(All preferred but not obligatory)

Prior Knowledge:
Mechanics
Quantum Mechanics and atomic physics
Thermodynamics
Fluid Dynamics
Electrodynamics

401-7855-00L Computational Astrophysics (University of Zurich) W+ 6 credits 2V L. M. Mayer

Objective
Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes

Content
1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

Literature
Galactic Dynamics (Binney & Tremaine, Princeton University Press),
Computer Simulation using Particles (Hockney & Eastwood CRC press),
Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

Prerequisites / notice
Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial

651-2338-00L Remote Sensing and Geographic Information Science III (University of Zürich) W+ 5 credits 2V+3U University lecturers

Abstract
The course "Grundlagen der Fernerkundung" (Principles of Remote Sensing) introduces the underlying principles of remote sensing and a range of fundamental concepts for understanding, handling and manipulating remote sensing data and images. It provides first details on optical image geometries as well as image classification and time series analysis.

Objective
The learning goals of this module comprise the following aspects:
- Understanding and being able to explain fundamental concepts of remote sensing
- Knowing basic image understanding techniques and being able to apply these to optical imagery.
- Being able to choose and apply appropriate data analysis methods to solve a given remote sensing task
- Being able to interpret data, critically discuss the results and draw reasonable conclusions

651-4257-00L Specialisation in Remote Sensing: SAR and LIDAR (University of Zurich) W+ 6 credits 2V+2U University lecturers

Prerequisite: Remote Sensing Methods (UZH Module Code: GEO0443)

Abstract
This module introduces advanced remote sensing methods and techniques to interpret and analyse RADAR and LiDAR data. The variety of topics covered in this module begin with image focussing, move through geometric and radiometric data processing, as well as interferometric and polarimetric evaluations.

Objective
The aim of the module is to give students a thorough understanding of the concepts, principles and processing of SAR and LiDAR data. Students will be able to carry out typical workflows in data processing and product generation. They will also be able to assess the quality of data products and understand the nature of errors that can affect the datasets. Students will acquire both theoretical and practical knowledge and understanding of aerial and satellite SAR imagery and LiDAR point cloud data. They will be able to derive solutions to problems presented and will have an understanding of applications including associated limitations.
Content
The module provides students with the skills to use state of the art software tools (e.g. SNAP, Matlab) to process data sets and develop new tools within existing frameworks. Examples of SAR applications treated include glacier and volcano monitoring, as well as height estimation using interferometry. Laser scanning exercises are focused on understanding LiDAR intensity, terrain model creation and their respective uncertainties and terrestrial laser scanning methods and applications. The module is composed of the lecture GEO 443.1, which teaches the underlying principles, and the exercise GEO443.2, which conveys important methods and skills of data processing and analysis.

651-4263-00L Remote Sensing and Geographic Information Science V (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: GEO371
Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract
The course “Methoden der Fernerkundung” (Remote Sensing Methods) introduces advanced remote sensing methods and techniques for interpreting and analyzing optical, RADAR and LiDAR data. The large variety of topics covered in this module range from radiative transfer over-encounters to the coursework on geometric and radiometric data processing techniques.

Objective
At the end of the module, students should: • Have a thorough understanding of advanced image understanding techniques and can apply these to optical, RADAR and LiDAR imagery. • Be able to choose the appropriate methods and use them to solve a given real-world task. • Be able to write basic programming scripts and use common remote sensing software to analyze geospatial data. • Be able to work scientifically on a given project (e.g. defining hypothesis and research questions). • Be able to comprehensively interpret data, critically discuss the results and draw the main conclusions.

651-4269-00L Specialisation in Remote Sensing: Spectroscopy of the Earth System (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: GEO442
Prerequisite: Remote Sensing Methods (UZH Module Code: GEO371)
Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract
The Spectroscopy of the Earth System course series outlines key contributions of imaging spectroscopy to advance understanding of the Earth System. Various Earth spheres (i.e. Atmosphere, Biosphere, Cryosphere, Hydrosphere, and Pedosphere) are addressed and spectroscopic approaches to quantify biogeochemical ecosystem properties and Earth surface processes are discussed.

Objective
The aim of the module is to give students a thorough understanding of the concepts, principles and processing of imaging spectroscopy data applied to various spheres of the Earth system. Students will be able to carry out typical workflows in data acquisition, processing and product generation. They will be able to assess the quality of the products and the nature of the errors affecting the product. Students will acquire both theoretical and practical knowledge and understanding of ground-based, aerial and satellite spectrometry data. They will be able to derive solutions to given problems and will have an understanding of diverse Earth sphere applications and associated limitations of learned techniques.

Content
The individual lectures inherently focus on fundamentals of radiation interaction with the atmosphere and the surface, as well as on aspects of data acquisition, quality assessment and pre-processing. A comprehensive set of methods to extract information and from imaging spectroscopy data is described (e.g. spectral feature analysis, spectral unmixing, radiative transfer modeling, reflectance and fluorescence retrieval, calculation of spectral albedo). The module is composed of the lecture GEO 442.1, outlining the underlying principles, and the exercise GEO442.2, conveying important methods and skills of data processing and analysis.

651-7101-00L Space Life Sciences and Gravitational Biology (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: BME347
Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract
The main objective of the course is to introduce into the cross-disciplinary research approach in space life sciences and gravitational biology.

Objective
At the end of this module, the student shall be able to:
- Describe the basics of the current knowledge how the gravitational force affects cellular systems
- Understand options and constraints of the research platforms parabolic flights, suborbital ballistic rockets, International Space Station
- Define objective and requirements of a space experiment
- Know the basic procedures of the design and integration process of a space experiments
- Analyze, discuss and present research in the field of Space Life Sciences and Gravitational Biology

Content
The course combines biological, physiological, medical, technical and operational aspects of experiments in space and gives an introduction in gravitational biology in cellular systems, in space physiology and in space medicine and in different research platforms from parabolic flights to suborbital ballistic rocket missions up to International Space Station. In the exercise "Learning by Mission", students will learn to design a biological space experiment and in the "space seminar" to understand and to discuss new research results in paper presentations. The course will be completed by presentations from space industry and an excursion.

651-7102-00L Introduction to Astrobiology (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: AST201
Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Content
The individual lectures inherently focus on fundamentals of radiation interaction with the atmosphere and the surface, as well as on aspects of data acquisition, quality assessment and pre-processing. A comprehensive set of methods to extract information and from imaging spectroscopy data is described (e.g. spectral feature analysis, spectral unmixing, radiative transfer modeling, reflectance and fluorescence retrieval, calculation of spectral albedo). The module is composed of the lecture GEO 442.1, outlining the underlying principles, and the exercise GEO442.2, conveying important methods and skills of data processing and analysis.
### Abstract
An overview of astrobiology - the study of the origin, evolution of life on Earth, the possibility of life on other worlds and how we can discover its presence. We address some old and fascinating questions: where we came from, where we are going, are we alone in the universe and what life could be like out there amongst the stars.

### Content
1. What is life? Characteristics from replication to thermodynamics.
2. How life works I: Biochemistry of life, from the cell to the ribosomes and genetic code
3. How life works II: Extremes of life on Earth, from archaea to tardigrades
4. Evidence for first life, conditions on the early Earth
5. Abiogenesis I: The last common ancestor and the origin of organic molecules
6. Abiogenesis II: How to form a replicating evolving living thing
7. Habitability I: Lessons from Earth, our evolving Sun, climate history, feedback loops
8. Habitability II: Carbon cycle, history of oxygen, role of our Moon
9. Life in our solar system - the grand tour, Mercury to Mars
10. Life in our solar system - the Moons of Jupiter and Saturn
11. Planet formation - origin of the Earth
12. Exoplanets, discovery, characterisation and properties
13. The search for life out there
14. Galactic habitability and alien anatomy

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>UZH Module Code</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>651-7103-00L</td>
<td>Vital Functions: Measurements on the Human Body (University of Zurich)</td>
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<tr>
<td>651-7104-00L</td>
<td>Spatial Ecology and Remote Sensing (University of Zurich)</td>
<td>2</td>
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<tr>
<td>651-7105-00L</td>
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<td>651-7106-00L</td>
<td>Computational Astrophysics (LAB &amp; LECTURE)</td>
<td>10</td>
<td>AST246</td>
<td>University lecturers</td>
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**Objective**
By the end of this module, the students are able to: I) assess human vital functions, II) describe the working principle of the employed measurement systems, III) link the measured parameters to cardiovascular, respiratory, muscular and metabolic physiology.

**Content**
- The monitoring of vital functions is essential for medical diagnosis and treatment. In this block course, we will evaluate vital functions and their adaptation to changing conditions by performing measurements on human subjects. Targeted lectures to elucidate the principles of measurement and their link to human physiology will supplement the hands-on sessions.

**Objective**
The course is an introduction to scientific concepts and methods in spatial ecology. Spatial ecological patterns and processes are discussed and methods to assess and analyze spatial relations are introduced. The course has a focus on satellite-derived environmental data and their spatial analysis with respect to vegetation distribution and activity, and animal movement.

**Content**
This course is to develop knowledge and spatial analytical and mapping skills that can be applied in the master or PhD thesis to solve ecological questions and present results meaningfully.

**Objective**
To improve the knowledge base of all MSc and PhD students in Computational Science. This knowledge will also prepare the PhD students for questions during their eventual closed session exam, but in general will improve the performance of all students faced with computational questions during talks/conferences.

**Content**
The course includes lectures, hands-on computer labs, and a literature study relating to the theory. The lectures introduce the spatial component of ecological questions and methods to assess spatial patterns and relationships with processes. During computer labs, the students will run exercises to introduce them to ArcGIS and get first skills in handling spatial data (including remote sensing data) and analyses.

**Objective**
Towards the end of the course, students do their own project based on provided or potentially own scientific data sets. The aim of the course is to develop knowledge and spatial analytical and mapping skills that can be applied in the master or PhD thesis to solve ecological questions and present results meaningfully.
Ziel ist das Einüben der methodischen Grundkompetenzen anhand einer konkreten Fragestellung im Seminar; die gewonnenen Erkenntnisse sollen sodann in einer schriftlichen Arbeit selbständig umgesetzt werden können.

Regisseurs, ein Genre, eine Stilrichtung, ein filmhistorisches oder zeitgenössisches Thema.

Die Wahlmodule «Aufbau Seminar» führen in wechselnde filmwissenschaftliche Fragestellungen ein, sei es im Hinblick auf das Werk eines Regisseurs, ein Genre, eine Stilrichtung, ein filmhistorisches oder zeitgenössisches Thema.

Erkenntnisse sollen sodann in einem schriftlichen Beitrag selbständig umgesetzt werden können.

Das Modul mit anschliessender Visionierung bietet Gelegenheit zur vertieften Diskussion des analytischen Basisinstrumentariums; es umfasst Textlektüren ebenso wie die intensive Auseinandersetzung mit einzelnen Filmen.

1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility.
2. Large-N gravity calculation, collisionless N-body systems and their simulation.
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

651-7107-00L Kosmos, Kosmologien und Worldbuilding im Kino (Universität Zürich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 255i003a

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsess/en/studies/application/deadline

Abstract

Die Wahlmodule «Aufbau Seminar» führen in wechselnde filmwissenschaftliche Fragestellungen ein, sei es im Hinblick auf das Werk eines Regisseurs, ein Genre, eine Stilrichtung, ein filmhistorisches oder zeitgenössisches Thema.

Objective

Ziel ist das Einüben der methodischen Grundkompetenzen anhand einer konkreten Fragestellung im Seminar; die gewonnenen Erkenntnisse sollen sodann in einer schriftlichen Arbeit selbständig umgesetzt werden können.

Content

Das Modul mit anschliessender Visionierung bietet Gelegenheit zur vertieften Diskussion des analytischen Basisinstrumentariums; es umfasst Textlektüren ebenso wie die intensive Auseinandersetzung mit einzelnen Filmen.

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2. Large-N gravity calculation, collisionless N-body systems and their simulation.
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

701-1241-00L Atmospheric Remote Sensing

The course will provide advanced physical understanding on the fundamentals of passive and active remote sensing, measuring sensors and retrieval methods. A series of diverse remote sensing applications will be presented, including measurements/retrievals of various atmospheric composition parameters (ozone, aerosols, clouds, others) from surface based and satellite based instruments.

The first aim of the lecture is to provide an in-depth understand of the physical aspects and basic laws on the fundamentals of remote sensing to the students. The lectures will provide a basic to intermediate understanding of radiative transfer of electromagnetic radiation through the atmosphere, covering the spectrum from UV to thermal. Examples of atmospheric components that will be addressed are: ozone, aerosols, greenhouse gases, clouds, water vapor.

In addition, measuring sensors used from the surface or from satellites and the relevant retrieval methods based on passive and active remote sensing of atmospheric composition will be presented (e.g. Spectroscopic, filter radiometers, Lidars and others). Finally, we aim to demonstrate a series of diverse remote sensing applications, including atmospheric composition measurements and retrievals from surface- and satellite-based instruments, including calibration and validation aspects.

The exercises will be embedded in the overall course lectures to provide hands-on experience with the measurements and retrieval methods conducting measurements and organizing small field experiments. Also with the use of atmospheric datasets available from specific instruments (e.g. satellite sensors) and networks (e.g. AERONET, GAWPPR).

Applications

- 3 introductory courses on climate variables, sensors, solar measurements and radiative transfer basics
- 7 courses including reomote sensing techniques on solar UV measurements, total column ozone, trace gases, greenhouse gases, aerosols, cloud retrievals and lidar active remote sensing.
- 3 exercises:
  - a. Conducting sun photometric measurements in the field and retrieve aerosol optical depth, including a visit in Davos, World Calibration Center
  - b. Exploring ground and satellite based solar UV. Ozone and aerosol measurements
  - c. Using radiative transfer modeling tools

Lecture notes

Lecture slides will be provided via Moodle before every lecture.

Prerequisites / notice

none
### Planetary Science

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>103-0187-01L</td>
<td><strong>Space Geodesy</strong></td>
<td>W+</td>
<td>6</td>
<td>4G</td>
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</table>

**Abstract**


**Objective**

- Describe the major observation techniques in space geodesy
- Describe the necessary modeling and analysis approaches to derive geodetic products of highest quality
- Select the appropriate space geodetic data for scientific investigations
- Analyze the space geodetic data for scientific purposes
- Interpret the scientific results

**Content**

Overview of GNSS, Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments and observation equations.

Modelling of the station motions and the estimation of station coordinates. Basics of wave propagation in the atmosphere. Signal propagation in the ionosphere and troposphere for the different observation techniques and the determination of atmospheric parameters.

Equation of motion of the unperturbed and perturbed satellite orbit. Osculating and mean orbital elements. General and special perturbation theory and the determination of satellite orbits.

**Lecture notes**

Script M. Rothacher "Space Geodesy"

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**Competencies**

<table>
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<tr>
<th>Competencies</th>
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<th>Method-specific Competencies</th>
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**Abstract**

This course provides students with a basic understanding of the science of cosmic dust in the solar system and how to measure it with space-based satellites and instrumentation. The lectures include the physical processes of both interplanetary and interstellar dust, trajectory simulations (i.e. orbital dynamics), in situ measurement techniques, and mission design aspects.
Cosmic dust is an important building block for planets and towards life. This course provides students with a basic understanding of the science of cosmic dust in the solar system, and how to measure it with space-based satellites and instrumentation. The lectures include the physical processes of both interplanetary and interstellar dust, trajectory simulations (i.e. orbital dynamics), in situ measurement techniques, and mission design aspects.

At the end of the course, students are able to classify the different types of dust in the solar system, and to relate them to their sources, sinks, their importance for planetary science and astronomy, physical processes, and appropriate measurement techniques. They will be able to simulate dust trajectories and use them to gain insight in how orbital dynamics and the space environment shape them. Students can design a basic concept of a space mission for dust measurements. The skills taught in this course will be useful to students in a broader way for planetary sciences.

While thousands of extrasolar planets are known to orbit stars other than the Sun, Earth is - until now - the only planet known to be habitable. This lecture takes an interdisciplinary view on Earth as a habitable planet, how it formed, evolved, allowed life to flourish, and how its future might look like. Would we be able to identify another Earth-like planet amongst the population of exoplanets?
Objective Attending students will
• understand Earth place in the cosmos
• learn tools to discern the history of Earth and other planets
• explore the origin and co-evolution of Earth and life
• put Earth in context with extrasolar planets

Content This lecture focuses on our home planet - Earth - from an interdisciplinary perspective. As the search for habitable - potentially even inhabited - extrasolar planets is one of the most dynamic research fields in modern astrophysics, understanding what makes a planet habitable is a topic of increasing importance; and a highly interdisciplinary topic. In broad brushes, this lecture will discuss the building blocks of planetary systems and their formation, how we can learn about the history of Earth and other planets, what major epochs we can identify over the course of Earth’s 4.5 billion year history, when life arose on Earth and what impact it had on Earth’s evolution, how the future Earth might look like, and - last but certainly not least - how we can search for an Earth-like planet in our cosmic neighbourhood and what our chances are to be successful.

651-4037-00L Mineral Resources I
Can be chosen as an elective course within the Bachelor. Prospective MSc-Students attending the module "Mineral Resources" should attend Mineral Resources I and II in the first year of their MSc studies.

Objective Understanding the fundamental processes of hydrothermal, magmatic and supergene ore formation, recognising and interpreting mineralised rocks in geological context

Content (a) Principles of hydrothermal ore formation: base metal deposits in sedimentary basins. Practical classification of sample suites by genetic ore deposit types. Mineral solubility and ore deposition, principles & thermodynamic prediction using activity diagrams. Driving forces and structural focussing of hydrothermal fluid flow
(b) Introduction to orthomagmatic ore formation. Chromite, Ni-Cu sulphides and PGE in layered mafic intrusions. Distribution coefficients between silicate and sulphide melts. Carbonatites and pegmatite deposits.
(c) Introduction to supergene residual deposits with emphasis on Ni laterites and bauxites

Lecture notes Notes handed out during lectures

651-4015-00L Earthquakes I: Seismotectonics
If you're interested in knowing more about the relationship between seismicity and plate tectonics, this is the course for you. (If you're not that interested, but your program of study requires that you complete this course, this is also the course for you.)

Objective The aim of the course is to obtain a basic understanding of the physical process behind earthquakes and their basic mathematical description. By the conclusion of this course, we hope that you will be able to:
- describe the relationship between earthquakes and plate tectonics in a more sophisticated and complete way
- explain earthquake source representations of varying complexity;
- address earthquakes in the context of different tectonic settings;
- explain the statistical behaviour of global earthquakes
- describe and connect the ingredients for a seismotectonic study

Content The course features a series of 14 meetings, in which we review some fundamentals of continuum mechanics and tensor analysis required for a complete understanding of the relation between earthquakes and plate tectonics. Our goal is to help you understand deformation the small scale (fault) to the scale of plate tectonics. We will tell you about several ways to represent an earthquake source; we'll present these in order of increasing sophistication. You will enjoy (at least) a computer/class exercise and a guest lecture.

Topics covered in the course include:
- review of stress and deformation in the Earth, stress and strain tensors, rheology and failure criteria, fault stresses, friction and effects of fluids
- earthquake focal mechanisms; relationship between stress fields and focal mechanisms;
- seismic moment and moment tensors;
- crustal deformation from seismic, geologic, and geodetic observations;
- earthquake stress drop, scaling, and source parameters;
- global earthquake distribution; current global earthquake activity;
- different seismotectonic regions; examples of earthquake activity in different tectonic settings.

Lecture notes Course notes will be made available on a designated course web site. Most of the topics discussed in the course are available in the book mentioned below.

Prerequisites / notice
Basic knowledge of continuum mechanics and rock mechanics, as well as notion of tensor analysis is strongly suggested. We recommend to have taken the course Continuum Mechanics (generally taught during the Fall semester).

This course will be taught in fall 2017 and it will be followed by Earthquakes 2: Source Physics in Spring 2018. The course will be evaluated in a final written test covering the topics discussed during the lectures. The course will be worth 3 credit points, and a satisfactory total grade (4 or better) is needed to obtain 3 ECTS. The course will be given in English.

651-4041-00L Sedimentology I: Physical Processes and Sedimentary Systems

Abstract
Sediments preserved a record of past landscapes. This course focuses on understanding the processes that modify sedimentary landscapes with time and how we can read this changes in the sedimentary record.

Objective
The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change. They discuss the advantages and pitfalls of the method and look beyond. In particular we pay attention to introducing the importance of considering entire sediment routing systems and understanding their functioning.

Content
Details on the program will be handed out during the first lecture.

Literature
The sedimentary record of sea-level change
Angela Coe, the Open University.
Cambridge University Press.

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.

651-4143-00L Geobiology

Abstract
We will study traces in the lithosphere that have been left behind by organisms during the course of Earth history and mineral components, which were built through biological processes or used as sources of energy and nutrients by organisms. Traces of life from the past will be compared with the development of the diversity of today’s organisms.

Objective
The course will allow you to ask questions about the origin and the evolution of life on Earth, to understand contemporary hypotheses and create new methods of developing them further. Theory is supplemented with observations in the field, exercises and the application of simple mathematical models. The course will enable you to integrate geobiological knowledge into topics that will be taught in subsequent earth science courses and into the current understanding of Earth history. You will learn to better understand modern geological settings and, if necessary, to recommend biogeochemically well-founded and responsible interventions or protective measures.

Content
The course focuses on (a) geobiological cycles that play major roles in Earth history in aquatic and terrestrial ecosystems, (b) biosynthetic and metabolic processes, which are essential for life, (c) organisms which regulate and maintain geochemical cycling, and (d) chemical signals of past life in the geological record.

Accordingly, we must understand
- how biological cells and its components are built from essential elements and molecules,
- how cells function and which life styles organisms developed,
- where organisms can exist and which factors select for their presence,
- where biologically useable forms of energy come from, and under which conditions they can be exploited,
- how biological metabolism can change environmental conditions and composition,
- which biological products can lead to signals preserved in the rock record, and how biomolecules and elements are altered in sedimentary deposits,
- how organic and inorganic components are cycled through the biosphere, and how biogeochemical cycles function,
- how “biological innovations” evolved and changed in response to environmental changes.

Applied Case Studies, which supplement and illustrate the contents:
- Scientific applications of geobiological knowledge are found in fields like Microbial Ecology, Geochemistry, Palaeontology, Sedimentology, Petrology, Ocean Research, Environmental Sciences, Astrobiology and Archaeology.
- Practical applications of geobiological knowledge are needed in fields like stabilisation of existing and design of safe waste repositories, surveilling ground water resources, sewage treatment, exploitation of and prospecting for fossil carbon sources, soil remediation, mineral exploration and teaching, forensic science and medicine.

Prerequisites / notice
Als integraler Bestandteil der Vorlesung wird eine Exkursion durchgeführt.
Mit der Belegung akzeptieren die Studierenden die Allgemeinen Geschäftsbedingungen für Exkursionen und Feldkurse des D-ERDW: https://www.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/studium/exkursionen/AGB_ERDW_Exkursionen_dt.pdf

Competencies
- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
  - Decision-making fostered
  - Problem-solving assessed
- Social Competencies
  - Communication fostered
  - Cooperation and Teamwork fostered
- Personal Competencies
  - Creative Thinking fostered
  - Critical Thinking assessed

651-4233-00L Composition and Evolution of the Earth and Planets

Abstract
In this Masters-level course, we address the formation and evolution of the rocky planets with a particular focus on the chemical and isotopic make-up of the Earth and its mantle. This is achieved through analysis of its partial melting products in different tectonic settings and through time.

Objective
Students will gain an insight into cutting-edge research in planetary science and the geochronology evolution of Earth's mantle. The objective is to be able to synthesise scientific studies whose conclusions differ, and, eventually, to form a coherent opinion by debating and scrutinising the available data. This will be achieved by weekly lectures and exercises throughout the semester, culminating in a debate on a topical subject in Earth and planetary science.

651-4241-00L Numerical Modelling I and II: Theory and Applications

Abstract
Details on the program will be handed out during the first lecture.

Objective
Students registering for the course confirm having read and accepted the terms and conditions for excursions and field courses of D-ERDW: https://ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/studium/exkursionen/AGB_ERDW_Exkursionen_en.pdf

Competencies
- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
  - Decision-making fostered
  - Problem-solving assessed
- Social Competencies
  - Communication fostered
  - Cooperation and Teamwork fostered
- Personal Competencies
  - Creative Thinking fostered
  - Critical Thinking assessed
In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasise a hands-on learning approach rather than extensive theory.

Objective

The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e. using a similar approach to solve different applications, and modularity, i.e. re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.

Content

A provisional week-by-week schedule (subject to change) is as follows:

Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity with stream function/vorticity formulation.


Weeks 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


Week 14: Final project description for slab breakoff modeling.

GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Literature


Competencies

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651-5107-00L

Physics of Planetary Interiors W+ 3 credits 2G A. Khan

Abstract

Planetary science encompasses the study of the physical and chemical nature of planetary bodies both in the Solar System and in extrasolar systems. The formation of planets, the forces that shaped their orbits and the processes that molded their interiors are part of planetary science. Understanding these complex phenomena requires knowledge from various geo- and astrophysically-related fields.

Objective

The goal of this course is to provide students with quantitative understanding of planetary science. The emphasis in this course will be on the theoretical development of the fundamentals needed for understanding planetary materials, planetary formation and evolution, and planetary interiors.

Content

The course will loosely be divided into ~14 lectures on various topics to be held by the main lecturer. In addition to the lectures, the students will solve a number 'take-home' problems and will hand in reports.

Topics that will be covered in the course include:

1. Elasticity
2. Equations of state
3. Thermodynamics applied to mantle materials
4. Harmonicity and anharmonicity
5. Tidal potential, gravity and figure of a planet
6. Planetary rotation, precession and nutation
7. Orbital evolution and tidal dissipation
8. Heat
9. Free oscillations of a planet

Prerequisites / notice

Completion of "651-4130-00 Mathematical Methods" is required.
Completion of "651-4013-00L Potential Field Theory" is required.
Completion of "651-4096-00L Inverse Theory for Geophysics I: Basics" would be helpful.
This course focusses on the principles (fundamentals) and basic concepts of rock mechanics and rock engineering (e.g. tunnelling, rock driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Content
Plate tectonic frame work: earth cooling and mantle-plate interaction, three kinds of plate boundaries and their roles and characteristics, cycle of oceanic lithosphere, longlifety and growth of continents, supercontinents. Rheology of layered lithosphere and upper mantle.

Obduction systems
Collisions systems
Extensional systems
Basin evolution
Passive and active continental margin evolution

Literature

651-3521-00L Tectonics W+ 3 credits 2V W. Behr, S. Willett

Abstract
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Objective
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Assessment of mechanisms responsible for plate movements (the Earth as a heat transfer machine, dynamics of earth mantle, plate driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Content
Plate tectonic frame work: earth cooling and mantle-plate interaction, three kinds of plate boundaries and their roles and characteristics, cycle of oceanic lithosphere, longlifety and growth of continents, supercontinents. Rheology of layered lithosphere and upper mantle.

Obduction systems
Collisions systems
Extensional systems
Basin evolution
Passive and active continental margin evolution

651-4025-00L Rock Mechanics and Rock Engineering W+ 4 credits 4V V. Gischig, P. A. Selvadurai

Abstract
This course focusses on the principles (fundamentals) and basic concepts of rock mechanics and rock engineering (e.g. tunnelling, rock slope stability).

Objective
The course aims to introduce the fundamentals and basic concepts of rock mechanics and generic rock engineering. The student shall understand how rocks behave at different scales, under various artificial loads and in the shallow subsurface (a few km below ground). The link between rock mechanics, geology, hydrogeology and tectonics (i.e. the conditions under which the rock formed) will be clearly established.

Content
This course focusses on the principles (fundamentals) and basic concepts of rock mechanics and generic rock engineering. The course is compulsory for the MSc Eng Geol. The applications of rock mechanical principles and rock engineering methods are extensively covered in subsequent courses.

Lecture notes
Written course documentation available on our homepage: https://www.ethz.ch/content/specialinterest/erdw/geological-institute/engineering-geology/en/teaching/msc/fall/rock_mechanics.html

651-3440-02L Geophysics III W+ 4 credits 3G A. Jackson, M.-A. Meier, P. Tackley

Abstract
This course builds on Geophysik I and Geophysiik II, broadening the students' education in seismology, geodynamics and geodynamo theory, by considering various specific topics of particular interest.

Objective
To teach students the basics of observational seismology, earthquake source seismology, seismotectonics and the principle of seismic tomography, mantle convection over Earth history, structure of the oceanic and continental lithosphere, plate tectonics, hotspots, global heat flux, dynamo operation and magnetic field generation in Earth, planets, the Sun and stars; electromagnetism to probe the mantle.

Content
Observational seismology, earthquake source seismology, seismotectonics and the principle of seismic tomography. Mantle convection over Earth history, structure of the oceanic and continental lithosphere, plate tectonics, hotspots, global heat flux. Dynamo operation and magnetic field generation in Earth, planets, the Sun and stars; electromagnetism to probe the mantle.

701-0475-00L Atmospheric Physics W+ 3 credits 2G U. Lohmann

Abstract
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, especially prediction of showers and severe convective storms, and optical phenomena

Objective
Students are able
- to explain the mechanisms of convective storm formation using knowledge of thermodynamics and cloud microphysics.
- to interpret precipitation radar images
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

In the course "Atmospheric Physics", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined. Measurement methods are taught as well.
The course starts with introducing selected concepts of thermodynamics for atmospheric processes; The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to use thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in radiosonde ascents. Atmospheric mixing processes are introduced as a basis for fog formation. The concept of an air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

Lecture notes

Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=22731

Lecture slides will be provided via Moodle before every lecture.

Atmospheric Remote Sensing

The course will provide advanced physical understanding on the fundamentals of passive and active remote sensing, measuring sensors and retrieval methods. A series of diverse remote sensing applications will be presented, including measurements/retrievals of various atmospheric composition parameters (ozone, aerosols, clouds, others) from surface based and satellite based instruments.

- Explore major atmospheric measurement databases and use of the available data
- Interpretation of measurement and retrieval related results on atmospheric composition and solar radiation based on using combined retrieval data products

701-1241-00L Atmospheric Remote Sensing W+ 3 credits 2G J. Gröbner, S. Kazantzis

Abstract

Main objectives of the course and what the students will be able to explain and use at the end of it are:
- The major atmospheric laws used for the retrieval of atmospheric composition and solar radiation parameters
- Ground based and satellite based retrieval examples for major atmospheric constituents
- Practical and experimental aspects on measuring atmospheric aerosols through the use of relevant instrumentation
- Explore major atmospheric measurement databases and use of the available data
- Interpretation of measurement and retrieval related results on atmospheric composition and solar radiation based on using combined retrieval data products

Objective

Atmospheric passive and active remote sensing is connected with a large number of applications including: atmospheric composition, Earth-atmosphere radiative balance, atmospheric and weather prediction model assimilation, agriculture, energy and health related applications and many others.

The proposed lesson is divided in three sections including exercises:
- Fundamentals of remote sensing
- Sensors (surface based and satellites) and retrieval methods
- Applications

The first aim of the lecture is to provide an in-depth understand of the physical aspects and basic laws on the fundamentals of remote sensing to the students. The lectures will provide a basic to intermediate understanding of radiative transfer of electromagnetic radiation through the atmosphere, covering the spectrum from UV to thermal. Examples of atmospheric components that will be addressed are: ozone, aerosols, greenhouse gases, clouds, water vapor.

In addition, measuring sensors used from the surface or from satellites and the relevant retrieval methods based on passive and active remote sensing of atmospheric composition will be presented (e.g. Spectroradiometers, filter radiometers, Lidars and others).

Finally, we aim to demonstrate a series of diverse remote sensing applications, including atmospheric composition measurements and retrievals from surface- and satellite-based instruments, including calibration and validation aspects.

The exercises will be embedded in the overall course lectures to provide hands-on experience with the measurements and retrieval methods conducting measurements and organising small field experiments. Also with the use of atmospheric datasets available from specific instruments (e.g. satellite sensors) and networks (e.g. AERONET, GAWPFR).

More specific the course include:
- 3 introductory courses on climate variables, sensors, solar measurements and radiative transfer basics
- 7 courses including remote sensing techniques on solar UV measurements, total column ozone, trace gases, greenhouse gases, aerosols, cloud retrievals and lidar active remote sensing.

-3 exercises:
  a. Conducting sun photometric measurements in the field and retrieve aerosol optical depth, including a visit in Davos, World Calibration Center
  b. Exploring ground and satellite based solar UV. Ozone and aerosol measurements
  c. Using radiative transfer modeling tools

Finally, students are involved on presenting scientific literature on subjects they are interested in.

All exercises are conducted in student-forming teams

Lecture notes

Lecture slides will be provided via Moodle before every lecture.

Technical Competencies

- Methods conducting measurements and organiying small field experiments. Also with the use of atmospheric datasets available from specific instruments (e.g. satellite sensors) and networks (e.g. AERONET, GAWPFR).

- Interpretation of measurement and retrieval related results on atmospheric composition and solar radiation based on using combined retrieval data products
### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

#### Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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### 701-1271-00L Statistical Learning for Atmospheric and Climate Science

**W+ 3 credits 2G L. Gudmundsson, D. Nerini**

#### Abstract
This course offers a systematic introduction to statistical and machine learning methods with focus on applications in atmospheric and climate science. Focus is on the theoretical and mathematical basis of supervised statistical learning (advanced regression, nonparametric methods) and their application in practice with hands-on exercises.

#### Objective
Students:
- Understand the theoretical basis of machine learning
- Are familiar with overarching concepts such as bias-variance trade-off, cost-functions, hyper parameters, cross-validation
- Have good command of the theoretical basis of selected machine learning tools
- Are able to select the appropriate statistical learning tools to tackle atmospheric and climate research problems
- Can apply methods of statistical learning in atmospheric and climate research
- Data in atmospheric and climate research (data types, observations, models)
- Exploring properties of atmospheric and climate data (data in space and time, multivariate data)
- Concepts of supervised learning (bias variance trade-off, overfitting, cross-validation)
- Advanced linear regression (multiple linear regression, regularization)
- Non-linear regression (local linear regression, regression trees, gradient boosting, random forests, neural networks)
- Bootstrapping
- Keynote speakers showcasing recent topics in statistical learning and high-level applications for atmospheric and climate research

#### Literature

#### Prerequisites / notice
- Knowledge of introductory statistics
- Overview on the climate system
- Basic experience in a programming language
- Course is limited to 30 participants.

Exercises will be in the R for most of the sessions and in Python for deep learning.

#### Competencies

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#### Robotics

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<tr>
<td>151-0323-00L</td>
<td>Hands-on Self-Driving Cars with Duckietown</td>
<td>W+</td>
<td>4</td>
<td>4G</td>
<td>M. Di Cicco, A. Censi</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2315 of 2667
Abstract
This course is a hands-on introduction to self-driving cars using the Duckietown platform.

Each student is given a mobile wheeled robot and throughout the class must configure and program.

Objective
This course includes the basics of modeling, perception, planning, control, and learning for self-driving cars. The focus is on the integration and co-design of components and behaviors rather than algorithmic dept.

Content
Perception, planning, and control, leveraging primarily on vision data.

Lecture notes
Lecture notes, primarily in the form of slides and tutorials, will be accessible from Moodle. Additional materials can also be accessed from the EdX MOOC called “Self-driving cars with Duckietown”.

Literature
Course notes will be provided in an electronic form. These are some books that can be used to provide background information or consulted as references:
1. Siegwart, Nourbakhsh, Scaramuzza - Introduction to autonomous mobile robots;
2. Norvig, Russell - Artificial Intelligence, a modern approach.
3. Peter Corke - Robotics Vision and Control
4. Oussama Khatib, Bruno Siciliano - Handbook of Robotics

Prerequisites / notice
Students should have taken a basic course in probability theory, computer vision, and control systems, and should be familiar and comfortable with programming (Python), Linux, and GIT utilization.

In introduction to ROS will be given, but it's strongly advised that students have prior exposure to and experience with ROS to effectively navigate through the homework assignments and the final project.

A shared space will be available to work with the robots.

It's advised students will have ~5 square meters of free space at their place to work with their assigned robot.

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Prerequisites / notice
Number of participants limited to 30.

151-0325-00L Planning and Decision Making for Autonomous Robots

Abstract
Planning safe and efficient motions for robots in complex environments, often shared with humans and other robots, is a difficult problem combining discrete and continuous mathematics, as well as probabilistic, game-theoretic, and regulatory aspects. This course will cover the algorithmic foundations of motion planning, with an eye to real-world implementation issues.

Objective
The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments.

Content

Lecture notes
Lecture notes will be provided in an electronic form.

Literature
There is no required textbook, but an excellent reference is Steve Lavalle's book on “Planning Algorithms.”

Competencies

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Prerequisites / notice
Basic courses in optimization, control systems, probability theory, and should be familiar with modern programming languages and practices (e.g., Python, and/or C/C++). Previous exposure to robotic systems is a definite advantage.

It's advised students will have ~5 square meters of free space at their place to work with their assigned robot.

151-0371-00L Advanced Model Predictive Control

Abstract
Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

Objective
Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

Content
- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of regression methods
- Set-membership identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

Lecture notes
Lecture notes will be provided.

Prerequisites / notice
Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control in Spring Semester) strongly recommended.

151-0563-01L Dynamic Programming and Optimal Control

Abstract
This course includes the basics of modeling, perception, planning, control, and learning for self-driving cars. The focus is on the integration and co-design of components and behaviors rather than algorithmic dept.

Objective
This course includes the basics of modeling, perception, planning, control, and learning for self-driving cars. The focus is on the integration and co-design of components and behaviors rather than algorithmic dept.

Content
Perception, planning, and control, leveraging primarily on vision data.

Lecture notes
Lecture notes, primarily in the form of slides and tutorials, will be accessible from Moodle. Additional materials can also be accessed from the EdX MOOC called “Self-driving cars with Duckietown”.

Literature
Course notes will be provided in an electronic form. These are some books that can be used to provide background information or consulted as references:
1. Siegwart, Nourbakhsh, Scaramuzza - Introduction to autonomous mobile robots;
2. Norvig, Russell - Artificial Intelligence, a modern approach.
3. Peter Corke - Robotics Vision and Control
4. Oussama Khatib, Bruno Siciliano - Handbook of Robotics

Prerequisites / notice
Students should have taken a basic course in probability theory, computer vision, and control systems, and should be familiar and comfortable with programming (Python), Linux, and GIT utilization.

In introduction to ROS will be given, but it's strongly advised that students have prior exposure to and experience with ROS to effectively navigate through the homework assignments and the final project.

A shared space will be available to work with the robots.

It's advised students will have ~5 square meters of free space at their place to work with their assigned robot.

Competencies

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Prerequisites / notice
Number of participants limited to 60.

151-0325-00L Planning and Decision Making for Autonomous Robots

Abstract
Planning safe and efficient motions for robots in complex environments, often shared with humans and other robots, is a difficult problem combining discrete and continuous mathematics, as well as probabilistic, game-theoretic, and regulatory aspects. This course will cover the algorithmic foundations of motion planning, with an eye to real-world implementation issues.

Objective
The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments.

Content

Lecture notes
Lecture notes will be provided in an electronic form.

Literature
There is no required textbook, but an excellent reference is Steve Lavalle's book on “Planning Algorithms.”

Competencies

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Prerequisites / notice
There is no required textbook, but an excellent reference is Steve Lavalle's book on “Planning Algorithms.”

It's advised students will have ~5 square meters of free space at their place to work with their assigned robot.

A shared space will be available to work with the robots.

It's advised students will have ~5 square meters of free space at their place to work with their assigned robot.
Introduction to Dynamic Programming and Optimal Control.

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.


Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

**151-0615-00L Real-World Robotics - A Hands-On Project Class**

| W+ | 4 credits | 9A | R. Katzschmann |

**Abstract**
During this course, the students will develop an articulated robotic hand to solve a real-world robotic challenge: the robot must autonomously grasp and place objects. The students will learn the key theoretical concepts required to model, manufacture, control, and test their robot, alongside developing machine learning, programming, hardware, and engineering skills through the hands-on project.

**Objective**

- **Learning Objective 1: High-Level System Design**
  System and product design combined with requirement generation and verification are essential for this robotics project. The students will apply previously acquired system design knowledge and methods to a hands-on challenge.

- **Learning Objective 2: Robot Design and Simulation**
  Students will gain experience implementing and simulating robotic systems using modern design, modeling, and simulation techniques such as CAD and Isaac Gym. These techniques are essential in any design process to understand the expected system behavior. This requires thoroughly understanding the system's kinematics, dynamics, material, actuation principle, and physical limitations. Students will learn the theory and limitations behind modeling and simulation software.

- **Learning Objective 3: Robot Fabrication**
  Students will learn to use the previously designed CAD models for successful robot fabrication. Additionally, the iterative nature of the process will allow them to develop their critical thinking skills in assessing the limitations of their design as well as possible sources for improvements. Building the robot will equip students with essential skills for using robots in the real world.

- **Learning Objective 4: Control, Integration, and Testing**
  Students can directly apply the knowledge acquired in their control courses. They will gain theoretical knowledge on how to model and develop intelligent control algorithms. Perception methods and state-of-the-art machine-learning techniques will be taught. They will gain experience testing their robots' performance in both hard- and software to enhance their design and suggest future improvements.

- **Learning Objective 5: Robot production**
  Students will learn to choose between state-of-the-art industrial production processes to manufacture a soft robot by understanding their limitations and requirements. They will also learn how to optimize the robot design to account for a specific production process. During this course, the students will be divided into teams and each group will independently develop an articulated robotic arm to solve a real-world robotic challenge, which will take place at the end of the course. The students will learn the key theoretical concepts required to model, manufacture, control and test a soft robot, along with developing the programming, hardware and engineering skills through hands-on workshops.

This course is composed of tutorials, which will be available on the course website where the lecturer will provide all the necessary theoretical input, focus talks where robotic experts will present a particular aspect of the manipulator in detail, and workshops where the students will have the possibility to hands-on learn how to implement the solutions required to solve their challenge. Finally, there will be time slots to autonomously work on the manufacturing and development of the team's robot and an online forum will be available to help the students throughout the entire course.

This course is divided into six parts:

**Part 1: Challenge introduction**
- Identify the functional requirements necessary for the final challenge
- Evaluate the existing manipulator designs to optimize them for the specific task

**Part 2: Robot Design**
- Develop a CAD model based on the high-level system design.
- Integrate motors, pneumatics components, and other required materials in the design

**Part 3: Robot Fabrication**
- Come up with a fabrication method and plan using the presented fabrication skills.
- Fabricate the robot and its actuators based on the CAD model.
- Evaluate, modify, and enhance the fabrication approach.

**Part 4: Soft Robot Simulation**
- Simulate the soft manipulator through a simulation framework.
- Optimize the simulation parameters to reflect the experimental setup

**Part 5: Control, Integration, and Testing**
- Formulate the dynamic skills needed for real-life application.
- Develop traditional and learning-based control algorithms and test them in simulation.
- Integrate controller design into the fabricated robot.
- Build, test, fail, and repeat until the soft robot works as desired in simple tasks.
- Upgrade and validate the robot for performance in real-world conditions and verify requirements.

**Part 6: Product development**
- Propose a manufacturing process to bring the robot from a prototype to the final product
- Optimize the robot for production

**Lecture notes**
All class materials, including slides, video tutorials, and supporting literature, can be found on the class webpage (https://rwr.ethz.ch) and Moodle, supported by discussion and Q&A forums. Focus talks, Q&A sessions, and workshops will happen on Mondays between 14:00 and 16:00.


Prerequisites / notice

Registration for this course is limited due to the amount of resources needed to make this course happen. For this reason, it is required to apply through the following module: https://forms.gle/pnMHTCdzWgdwab519

The graded semester performance consists of the final team performance in the class challenge, a final team presentation and report, weekly Moodle quizzes, and attendance at the focus talks and workshops.

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151-0632-00L Vision Algorithms for Mobile Robotics (University of Zurich) W+ 6 credits 2V+2U D. Scaramuzza

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: DINF2039

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract

For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry (the algorithms behind Hololens, Oculus Quest, and the NASA Mars rovers).

Objective

Learn the fundamental computer vision algorithms used in mobile robotics, in particular: filtering, feature extraction, structure from motion, multiple view geometry, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry and Simultaneous Localization And Mapping (SLAM) (the algorithms behind Hololens, Facebook-Oculus Quest, and the NASA Mars rovers).

Content

Each lecture will be followed by a lab session where you will learn to implement a building block of a visual odometry algorithm in Matlab. By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.

Lecture notes

Lecture slides will be made available on the course official website: http://rgp.ifl.uzh.ch/teaching.html

Literature


Prerequisites / notice

Fundamentals of algebra, geometry, matrix calculus, and Matlab programming.

Note: If you are interested in taking UZH courses, you must register as an incoming mobility student at UZH. For details, see as follows:

UZH course enrollment for ETH student at University of Zurich (UZH) > Mobility within Switzerland – Incoming > Module Mobility: The easiest way to take individual modules/courses to supplement your studies at your home university is with module mobility. This option is not available to students who have dropped out of their home university or have been definitely excluded or banned from the relevant program > Application and Deadlines: Applications are submitted via the UZH application portal (https://www.uzh.ch/cmsssl/en/studies/application/chmobility.html)

Step-by-step guidelines on how ETH students can register for this course, are given on the official course website: https://rgp.ifl.uzh.ch/teaching.html

ATTENTION: When you book the course at UZH, you are automatically registered for the exam at UZH and you can unregister until the October deadline. After registering for the course, you as an ETH student need to check out your "**UZH email account**" to receive the related information from the lecturer.

151-0851-00L Robot Dynamics W+ 4 credits 2V+2U M. Hutter, R. Siegwart, J. Tordesillas Torres

Abstract

We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

Objective

The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.
The course consists of three parts: First, we will refresh and deepen the student’s knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

**Prerequisites / notice**

The course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls.

**Introduction to Aircraft and Car Aerodynamics**

**Objective**

- Aircraft aerodynamics: Atmosphere; aerodynamic forces (lift, drag); thrust.

**Abstract**

- An introduction to the basic principles and interrelationships of aircraft and automotive aerodynamics.
- To understand the basic relations of the origin of aerodynamic forces (ie lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components.
- Illustration of the intrinsic problems and results using examples.
- Using experimental and theoretical methods to illustrate possibilities and limits.

**Content**

- Aircraft aerodynamics: atmosphere, aerodynamic forces (ascending force: profile, wings. Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.

**Lecture notes**

Preparation materials & slides are provided prior to each class.

**Literature**

- Aircraft Aerodynamics:
  - Schlüchter,H. und Truckenbrodt, E: Aerodynamik des Flugzeuges (Bd I und II), Springer Verlag, 1960
  - Hoerner, S.F.: Fluid Dynamic Lift, Hoerner Fluid Dynamics, 1975

- Vehicle Aerodynamics

**Prerequisites / notice**

Students are required to attend all seven lectures to obtain credit. If a student must miss a lecture then attendance at a related special lecture will be accepted that is reported in a one page summary of the attended lecture. No exceptions to this rule are allowed.
This lecture focuses on the design of embedded systems using formal models and methods.

Besides the theoretical lecture, the course contains laboratory sessions where students transfer the learned theoretical aspects into praxis by programming a microcontroller and interfacing it with sensors and actuators. Students will be exposed to a commercial microcontroller, and the development board extend with a custom-designed embedded systems educational platform.

Specifically, the following topics will be covered in the course: hardware and software structures of embedded systems, low-level interface design, memory management, software architectures, communication between components, firmware design methodologies, firmware design using the C programming language, embedded real-time operating systems, real-time scheduling, shared resources, low-power, and low-energy designs as well as computational accelerators.

Lecture notes
Lecture material, publications, exercise sheets, and laboratory documentation will be available on the course's Moodle page.

Literature


Prerequisites / notice
Prerequisites: C programming, circuit theory, digital logic, binary number representations.

Recommended: basic knowledge of assembly programming and computer architecture.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

227-0447-00L Image Analysis and Computer Vision W+ 6 credits 3V+1U E. Konukoglu, E. Erdil, F. Yu

Abstract
Image segmentation. Motion extraction and tracking. 3D data extraction. Invariant features. Specific object recognition and object class recognition. Deep learning and Convolutional Neural Networks.

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
The course language is English.

227-0560-00L Computer Vision and Artificial Intelligence for Autonomous Cars W+ 6 credits 3V+2P C. Sakaridis

Abstract
Up until FS2022 offered as Deep Learning for Autonomous Driving

Objective
This course introduces the core computer vision techniques and algorithms that autonomous cars use to perceive the semantics and geometry of their driving environment, localize themselves in it, and predict its dynamic evolution. Emphasis is placed on techniques tailored for real-world settings, such as multi-modal fusion, domain-adaptive and outlier-aware architectures, and multi-agent methods.

Content
Students will learn about the fundamentals of autonomous cars and of the computer vision models and methods these cars use to analyze their environment and navigate themselves in it. Students will be presented with state-of-the-art representations and algorithms for semantic, geometric and temporal visual reasoning in automated driving and will gain hands-on experience in developing computer vision algorithms and architectures for solving such tasks.

After completing this course, students will be able to:
1. understand the operating principles of visual sensors in autonomous cars
2. differentiate between the core architectural paradigms and components of modern visual perception models and describe their logic and the role of their parameters
3. systematically categorize the main visual tasks related to automated driving and understand the primary representations and algorithms which are used for solving them
4. critically analyze and evaluate current research in the area of computer vision for autonomous cars
5. practically reproduce state-of-the-art computer vision methods in automated driving
6. independently develop new models for visual perception
The content of the lectures consists in the following topics:

1. Fundamentals
   (a) Fundamentals of autonomous cars and their visual sensors
   (b) Fundamental computer vision architectures and algorithms for autonomous cars

2. Semantic perception
   (a) Semantic segmentation
   (b) Object detection
   (c) Instance segmentation and panoptic segmentation

3. Geometric perception and localization
   (a) Depth estimation
   (b) 3D reconstruction
   (c) Visual localization
   (d) Unimodal visual/lidar 3D object detection

4. Robust perception: multi-modal, multi-domain and multi-agent methods
   (a) Multi-modal 2D and 3D object detection
   (b) Visual grounding and verbo-visual fusion
   (c) Domain-adaptive and outlier-aware semantic perception
   (d) Vehicle-to-vehicle communication for perception

5. Temporal perception
   (a) Multiple object tracking
   (b) Motion prediction

The practical projects involve implementing complex computer vision architectures and algorithms and applying them to real-world, multi-modal driving datasets. In particular, students will develop models and algorithms for:

1. Semantic segmentation and depth estimation
2. Sensor calibration for multi-modal 3D driving datasets
3. 3D object detection using lidars

Competencies

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227-0689-00L System Identification  
W+ 4 credits  2V+1U  R. Smith

Abstract
Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.

Objective
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Closed-loop identification strategies. Trade-off between controller performance and information available for identification.


Additional papers will be available via the course Moodle.

Prerequisites / notice
Control systems (227-0216-00L) or equivalent.

252-0535-00L Advanced Machine Learning  
W+ 10 credits  3V+2U+4A  C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-3110-00L Human Computer Interaction W+  8 credits 3V+2U+2A  C. Holz

Abstract

The course provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.

Objective

The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As well as understand the basic notions of Computational Design in a HCI context.

Content

The course will introduce students to several methods of analysing the user experience, showing how these can be used at different stages of system development from requirements analysis through to usability testing.

Students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

263-5210-00L Probabilistic Artificial Intelligence W+  8 credits 3V+2U+2A  A. Krause

Abstract

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit “intelligent” behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.

Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered

Personal Competencies

- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered

263-5902-00L Computer Vision W+  8 credits 3V+1U+3A  M. Pollefeys, S. Tang, F. Yu

Abstract

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.
Abstract
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

375-1504-00L
Physical Human Robot Interaction (pHRI)  W+  4 credits  2V+2U  O. Lamberty, P. Wolf

Abstract
This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

Objective
The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de-sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize user systems using both the training and evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Content
This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes
Will be distributed on Moodle before the lectures.

Literature

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2323 of 2667
Prerequisites / notice
The registration is limited to 26 students.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes.
http://www.relab.ethz.ch/education/courses/phri.html

### Competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**
- Communication: assessed

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

**Elective Courses**

At least 16 ECTS must be completed within the elective courses.
For the two deep tracks "Aerospace Engineering" and "Space Communication" the courses listed below are recommended.

- Further recommended elective courses in Aerospace Engineering from the deep track courses
- Further recommended elective courses in Space Communication from the deep track courses
- Recommended elective courses in Earth Observation (choose from deep track courses)
- Recommended elective courses in Planetary Science (choose from deep track courses)
- Recommended elective courses in Robotics (choose from deep track courses)

**Science in Perspective**

- Recommended Science in Perspective (Type B) for D-EAPS
- see Science in Perspective: Language Courses ETH/UZH
- see Science in Perspective: Type A: Enhancement of Reflection Capability

**Master’s Thesis**

**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

<table>
<thead>
<tr>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS: European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
Sport Teaching Diploma

Detailed information on the programme at: www.didaktischeausbildung.ethz.ch

Educational Science

Courses in the category Educational Science are listed under “Programme: Educational Science for Teaching Diploma and TC”.

Please note that the course unit number will change from autumn semester 2024 onwards. This change has no influence on the course units and achievements completed so far and will be recognized for the respective degree.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>871-0240-15L</td>
<td>Designing Educational Environments in Physical Education (EW2 Sport)</td>
<td>O</td>
<td>4</td>
<td>1S</td>
<td>H. Gubelmann, R. Scharpf</td>
</tr>
</tbody>
</table>

Abstract

Students learn principles of teaching beyond classroom and regular PE-Lessons:
- Planning and organizing camps and events
- Teaching the "Ergänzungsfach Sport"
- Long-term-curricula in PE
As a practical part students design the Outdoor event in EW4 of the following term.

Objective

Students know:
- How to plan events and camps
- To assess curricula critically and to use them properly
- How to combine theoretical and practical issues in the ‘Ergänzungsfach’

Content

1. LV Semestereinführung
2. LV Planung Outdoor-Weekend
3. LV Auswertung Outdoor-Event
4. LV Planung Event
5. LV Event-Präsentationen / Schlussveranstaltung
EW2 is compulsory requirement for EW4 Sport

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern, M. Rau</td>
</tr>
</tbody>
</table>

Abstract

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Objective

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content

Thematische Schwerpunkte:
- Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:
- Theoretische und wissenschaftliche Konstrukte werden zusammen mit ausgewählten wissenschaftlichen Untersuchungen in Form einer Vorlesung präsentiert. Die Studierenden vertiefen nach jeder Stunde die Inhalte durch die Auseinandersetzung mit den Aufträgen.
- In einem elektronischen Lerntagebuch. Über die Bedeutung des Gelernten für den Schulalltag soll reflektiert werden. Ausgewählte Tagebuchträume werden zu Beginn jeder Vorlesung thematisiert.

Lecture notes

Folien werden zur Verfügung gestellt.

Literature


Prerequisites / notice

This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom” or “Didaktisches Zertifikat”. It is about learning in childhood and adolescence.

Subject Didactics in Sport

Important: You can only enroll in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>557-0315-00L</td>
<td>Sports Didactics I</td>
<td>O</td>
<td>4</td>
<td>2V</td>
<td>A. Thoma</td>
</tr>
</tbody>
</table>

Abstract

Practical implementation in sports of general didactics, with the planning, implementation and evaluation of topics from all the sports-specific areas of tuition in secondary school Level II.

Objective

The students:
- Implement the objectives of general didactics in respect of the different types of sport at school.
- Master the planning, implementation and evaluation of topics from all the sports-specific areas of tuition.
- Gain an overview of the preparation necessary for the different requirements placed on a sports teacher at secondary school Level II.
- Try out different teaching structures, such as the lesson, teaching unit, block periods and extra units in sport in addition to those on the timetable.

Content

Implementation of practical sport into general teacher training with planning, execution and evaluation of the topics from all sport-specific areas of the education at this level in Section II.

Lecture notes

Skript unter: https://moodle-app2.let.ethz.ch/course/view.php?id=117>
### Professional Training in Sport

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>
| **557-0210-00L** | **Introductory Internship Sports**<br>
Simultaneous enrolment in Sports Didactics I (557-0315-00L) OR Sports Didactics II (557-0316-00L) is compulsory, depending on which of the Sports Didactics courses is taken first. | O    | 3    | 6P    | A. Thoma, further lecturers |
| **557-0208-00L** | **Teaching Internship Sports**<br>
Takes normally place at the end of the studies, before the examination lessons are conducted. | O    | 8    | 17P   | A. Thoma, further lecturers |
| **557-0203-01L** | **Mentored Work Subject Didactics Sport** | O    | 4    | 9A    | Supervisors |

### Literature
- Kernleermittel Jugend und Sport
- Lehramt-Studierende müssen die Fachdidaktik Sport I zusammen mit dem Einführungspraktikum Sport - LE 557-0210-00 - belegen.

Voraussetzung: Berufspraktische Übungen (557-0215-00L) absolviert.

- Disler P., Dida-Methodische Modelle in der Ausbildung, Dissertation in 2004, 152
- Loosch E., Allgemeine Bewegungslehre, Limpert Verlag Wiesbaden 1999
- Roth K. & K. Willeczek, Bewegungswissenschaft, Rowohlt Verlag Reinbek 1999
- Röthig P. Sportwissenschaftliches Lexikon, Schorndorf Verlag 2003
- Röthig P. & s. Grössing (Hrsg.) Bewegungslernen, Kursbuch 3, Wiesbaden 1990/3
- Disler P., Dida-Methodische Modelle in der Ausbildung, Dissertation in 2004, 152
- Loosch E., Allgemeine Bewegungslehre, Limpert Verlag Wiesbaden 1999
- Roth K. & K. Willeczek, Bewegungswissenschaft, Rowohlt Verlag Reinbek 1999
- Röthig P. Sportwissenschaftliches Lexikon, Schorndorf Verlag 2003
- Röthig P. & s. Grössing (Hrsg.) Bewegungslernen, Kursbuch 3, Wiesbaden 1990/3

**Prerequisites / notice**
- abgeschlossene Fachdidaktik Sport I oder Fachdidaktik Sport II
The teaching practice takes in 30 Sessions. It lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Objective
Students use their disciplinary skills and educational knowledge for teaching. They know how to judge topics of their subject and can present them in class. Teaching and classroom management in practice is the main target of this course; students have to find a balance between instruction and self-determined activity of their pupils. Together with their supervisors they learn to assess their tasks and achievements.

Content
Students apply their theoretical background in practice. By teaching sports lessons they improve their teaching skills and classroom management and learn how to interact with pupils. Together with their supervisor they develop an ability of critical reflection of their tasks.

Prerequisites / notice
Prerequisites for the Teaching Internship: all ECTS in Teaching Diploma Sports, apart from
- 3 ECTS Educational Science
- 4 ECTS Specialized Courses with Educational Focus
- 2 ECTS Examination Lessons

557-0220-00L Partial Teaching Internship Sport ■ 6 credits 11P A. Thoma, further lecturers

Abstract
The teaching practice takes in 30 Sessions. It lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Objective
Students use their disciplinary skills and educational knowledge for teaching. They know how to judge topics of their subject and can present them in class. Teaching and classroom management in practice is the main target of this course; students have to find a balance between instruction and self-determined activity of their pupils. Together with their supervisors they learn to assess their tasks and achievements.

Content
Students apply their theoretical background in practice. By teaching sports lessons they improve their teaching skills and classroom management and learn how to interact with pupils. Together with their supervisor they develop an ability of critical reflection of their tasks.

Prerequisites / notice
Prerequisites for the Teaching Internship: all ECTS in Teaching Diploma Sports, apart from
- 3 ECTS Educational Science
- 4 ECTS Specialized Courses with Educational Focus
- 2 ECTS Examination Lessons

557-0211-01L Examination Lesson I Sports ■ 1 credit 2P A. Thoma, further lecturers

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Objective
On the basis of a specified topic, the candidate shows that they are in a position
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Content

Lecture notes
Dokument: Schriftliche Vorbereitung für Prüfungslenkoheiten.

Prerequisites / notice
Nach Abschluss der übrigen Ausbildung.

557-0211-02L Examination Lesson II Sports ■ 1 credit 2P A. Thoma, further lecturers

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Objective
On the basis of a specified topic, the candidate shows that they are in a position
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Content

Lecture notes
Dokument: Schriftliche Vorbereitung für Prüfungslenkoheiten.

Prerequisites / notice
Nach Abschluss der übrigen Ausbildung.

Specialized Courses in Respec. Subj. w/ Educ. Focus & Further Subj. Didactics

Specialized Courses in Respective Subject with Educational Focus I
At least 6 CPs must be obtained in this category.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-1033-00L</td>
<td>History of Sports</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Gisler</td>
</tr>
</tbody>
</table>

Abstract
Comprehension for development and changes of sports from the ancient world to the present. Description of sports in services of national idea, from education and health promotion from the middle of the 18th century till this day.

Objective
Understanding for the development and adaptation of sports from the ancient world to present times.
The lectures set out to:

- Subject area of educational psychology
- Motivating students in physical education
- Building self-efficacy and strengthen the self-concept
- Promoting positive emotions and a positive attitude to anxiety
- Encouraging self-directed learning
- Leading classes and promoting cooperation
- Communicating with students efficiently
- Reflecting your own expectations critically
- Handling gender issues sensitively
- Promoting inclusion / Strengthening social and moral development
- Dealing with difficult students
- Evaluating achievements of students

Teaching materials for the individual lectures are provided to the students via moodle.

Lecture notes

Literature


- Autumn Semester 2024

- 2V

- 2 credits

- C. Herrmann

- Sport Pedagogy

- Development of pedagogical-psychological competences for the optimisation of future teaching activities.

- Subject with an Educational Focus Sport A

- Personal Competencies

- Social Competencies

- Method-specific Competencies

- A detailed program with additional references will be delivered at the beginning of the lecture.

- Subject-specific Competencies

- Method-specific Competencies

- Social Competencies

- Personal Competencies

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Subject with an Educational Focus Sport A

Competency application of research projects for schools

Introduction of sports pedagogical oriented research projects. Competency to a youth friendly movement and sports education. Competent pedagogical application of research projects in the field of movement and sport. Feed in of scientific findings to school lesson settings.
Objective
The students combine and apply general educational aims with a general and specific background of research projects. They know different educational concepts of the above mentioned, recognise its strengths and weaknesses and are able to apply concepts appropriate to the situation.
They are interested in the (thought-) processes of education and research in sports in Switzerland.
They use their knowledge of research matters to guide educational thought-processes.
They are interested in processes of research in sports.
They approach the research interest of their pupils with the knowledge of sports psychology, sports sociology, sports pedagogy, and sports history.

Content
Die Studierenden wenden die Bewegungs- und Lernziele des Sportunterrichts aus den kantonalen Lehrplänen im Unterricht an und können diese begründen.
Sie interessieren sich für die Prozesse der Forschung Im Sport
Sie erlernen anhand von Projektaufgaben die didaktische Anwendung der Sportpsychologie, Sportssoziologie, Sportpädagogik und Sportgeschichte und ziehen daraus Konsequenzen für den situativ-variabel orientierten Unterricht.
Sie setzen ihr Wissenschaftswissen ein, um bei den Lernenden Denkprozessen anzustoßen und zu begleiten.

Lecture notes
Skript unter: https://moodle-app2.let.ethz.ch/course/view.php?id=117

Literature
Literaturverweise erfolgen jeweils in den gewählten Fachbereichen

Prerequisites / notice
Auswahl von 2 aus 4 Angeboten:
a) Motor-Learning im Sport (Fachbereich Sportpsychologie)
- Vorlesung
- Praktische Umsetzung von Forschungsprojekten für die Schule
b) Sport im Spannungsfeld zwischen Ethik und Kommerz (Fachbereich Sportssoziologie)
- Vorlesung
- Praktische Umsetzung von Forschungsprojekten für die Schule
c) Mehrperspektivität im Sportunterricht (Fachbereich Sportpädagogik)
- Vorlesung
- Praktische Umsetzung von Forschungsprojekten für die Schule
d) Historische Entwicklung der Lehr und Lernmodell im Sportunterricht (Fachbereich Sportgeschichte)
- Vorlesung
- Praktische Umsetzung von Forschungsprojekten für die Schule
Alle Wahlfachangebote beinhalten:
- Sportwissenschaftliche Fachpraxis
- Praktische Umsetzung der Erkenntnisse für die Schule

Specialized Courses in Respective Subject with Educational Focus II
At least 6 CP's must be obtained in this category.
Further courses must be chosen from the "Sports Practice: In-depth Education".

Compulsory Elective Courses
At least 6 CP's must be acquired in this category.
Further courses must be chosen from "Sports Practice: In-depth Education and Specialized Education".

Sports Practice
The Teaching Diploma in Sports will only be granted to students holding a Master, Diploma or Licentiate degree in Human Movement Sciences and Sports or Health Sciences and Technology. Additionally, a Sports Practice encompassing 56 CPs is required. The Sports Practice can be partly conducted during the Bachelor and Master programmes in Sports.

Assessments

<table>
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<tr>
<th>Number</th>
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<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>557-0101-00L</td>
<td>Assessment Polysports</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>M. Altermatt</td>
</tr>
</tbody>
</table>

Abstract
Successful completion of the course "Assessment Polysports" is requirement for access to further practical sport courses. Basic skills in ball games, athletics, gymnastics, fitness, and dance are repeated and tested.

Lecture notes
During the semester the documents are steadily available electronically

Basic Education

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>557-0424-01L</td>
<td>Fitness I</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>R. Heynen, further lecturers</td>
</tr>
</tbody>
</table>

Abstract
Basic education in fitness: to acquire abilities and skills in the areas of strength, endurance, mobility, aerobics and prophylaxis

Objective
To gain knowledge of practical basics in the area of fitness
To obtain abilities and skills in the area of fitness such as strength, endurance, flexibility, aerobic dance, prevention

Content
- Prophylaktisches Fitnesstraining: Muskikondi
- Fitness test in Kraft und Ausdauer
- Grundlagen Krafttraining
- Haltung und Beweglichkeit
- Fitnessrends (Crossfit, TRX)
- Anwendungen für die Schule

Lecture notes
Sie wird im Unterricht abgegeben

Literature
- Taschenatlas der Anatomie, Bewegungsapparat, W.Platzer, Thieme Verlag
- Optimales Training, J.Weineck, Erlangen, Spitta Verlag
- Sportbiologie, J.Weineck, Erlangen, Perimed Verlag
- Sportanatomie, J.Weineck, Erlangen, Perimed Verlag
- ASVZ Trainingslehre, erhältlich in Polybuchhandlung ETH
Learning the basic elements in drills and games, learning (pre-)tactical elements (1-1, getting open, 2-2, backdoor cut, frontdoor cut, 3-3,

C. Ferrari

All kind of swimming:

- Schwimmen: Erwerben und festigen der Schwimmtechniken Rücken, Brust und Kraul sowie Grundform Delfin. Erwerben und Festigen available on Moodle

Swimming I

Apparatus Gymnastics and Trampoline I

Prerequisites: Assessment Polysports passed (or Assessment I, II or III).

Compulsory for Teaching Diploma Sports.

Abstract

To get to know and understand the basics of movement (core movements) and its respective actions and functions on apparatuses, on the floor and in acrobatics as well as to create individual and cooperative combinations according to qualitative criteria.

Objective

- The students should be able to:
  - acquire and consolidate apparatus related core movements as well as apply and create such combinations
  - utilize their own strength as well as the resulting impact in a differentiate way in order to precisely move the swinging, falling, and twisting body
  - gain orientation safety and room orientation while twisting and flying
  - gain sensitivity for social competences (e.g. to assist, to observe, to advise) within a small group.
- structural relationships within rotations (tumaround, handsprings and free somersaults)
- core poses as motor basic training
- variety of position modifications in handstands
- core movements and combinations on parallel bars, high bar, floor and in swinging rings
- different forms of vaulting as well as springing in movements like handstands and somersaults

Content

- Trampolinschule nach der Part-Methode, BASPO 2013

Literature

Wird abgegeben

Prerequisites / notice

Assessment I, II or III).

Swimming I

Prerequisite: Assessment Polysport passed (or Assessment I or II or III).

Compulsory for Teaching Diploma Sports.

Abstract

Basic education in swimming: swimming, diving, water polo and artistic swimming

Objective

All kind of swimming:
- learns to know and understand the individual basic techniques
- improvement of technical skills and crafts

Content

- Artistic Swimming: Erwerben und festigen Wassertreten, Paddeln, einzelne Grundfiguren.

Lecture notes

Wird abgegeben

Literature

- Swimsports.ch: Schweizerische Tests im Schwimmsport

Basketball I

Prerequisites: Assessment Polysports passed (or Assessment I, II or III).

Compulsory for Teaching Diploma Sports.

Abstract

Basketball-Basics:
Basic technical skills: dribbling/ballhandling, passing, shooting, footwork and defense related to the specific Basketball rules.
Tactical skills: 1 on 1, give & go, hand-off, pick & roll, pick & pop and the application of these skills in a game 3 on 3 on one basket.

Objective

The students know the technical basic Basketball elements (dribbling, changes of hand, stops, starts, footwork, pass, shot, defense), they can demonstrate them and use them correctly in a game situation 3 on 3 on one basket.

The students know the tactical Basketball elements (1 on 1, give & go, hand-off, pick & roll, pick & pop) and can apply these skills in a game 3 on 3 on one basket.

The students know the main rules of the game.

Content

Learning the basic elements in drills and games, learning (pre-)tactical elements (1-1, getting open, 2-2, backdoor cut, frontend cut, 3-3, give & go, hand-off, pick & roll, pick & pop, spacing) and assemble them into systems, that can be used in a game 3 on 3 on one basket.

Lecture notes

available on Moodle

Literature

- manual for monitors of the Swiss Youth & Sports program (available through the "Jugend & Sport" office, german / french / italian)
- Chervet, Michel: Basketball. Fundamental skills for offensive play. Video (german / french). Magglingen, BASPO, 2003 (CHF 34.-). Order at video@baspo.admin.ch
<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>fostered</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>fostered</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td></td>
<td>Project Management</td>
<td>Project Management</td>
<td>fostered</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
<td>Self-presentation and Social Influence</td>
<td>fostered</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
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<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
<td>Creativity and Critical Thinking</td>
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<td>Cooperation and Teamwork</td>
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<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
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<td>Customer Orientation</td>
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### Soccer I

**557-0514-03L** Soccer I W 2 credits 2G H. A. Russheim, P. C. Humbel

**Prerequisites:** Assessment Polysports passed (or Assessment I, II or III).

**Compulsory for Teaching Diploma Sports.**

**Abstract**

Acquisition/consolidation basic skills for soccer.

Support and development the individual conditions/talent/skill and introduction of basic methods will be treated.

**Objective**

Acquisition/consolidation basic skills in soccer.

Support and development the individual conditions/talent/skill want to be at the centre of attention.

The introduction of basic methods complete the aim of the course.

**Content**

**Technique:**
- Dribble, short passport play, get the ball under control, shot,
- Individual tactics:
  - offensive/defensive 1vs1; keep ball in own rows
- various contests in support of different techniques and tactics

**Prerequisites / notice**

1. Prerequisites:
- Small being able in soccer.
- Readiness to train.

2. Additional material
- wearing soccer shoes is mandatory
- wearing shin guards is mandatory

**Competencies**

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<th>Social Competencies</th>
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<td>Cooperation and Teamwork</td>
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**Personal Competencies**

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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</table>

### Handball I

**557-0522-01L** Handball I W 2 credits 2G F. Lüchinger

**Prerequisites:** Assessment Polysports passed (or Assessment I, II, or III).

**Compulsory for Teaching Diploma Sports.**

**Abstract**

Learn by playing - from three-a-side to four-a-side games. Game development takes place over the zone play of the game (2/1) or 3/2 to the game 4/4 or (6/6).

The introduced technical elements form the requirements for the tactically-orientated zone plays and are exclusively trained in the execution and formation steps.

**Objective**

The students improve their personal skills and demonstrate the game in teams as well as groups of 4 against 4.

They deepen the development of the game

They improve their personal skills with an individual emphasis on game and practice.

**Content**

Spiegell Handball lernen - Über das Spiel zum Spiel (Vom Spiel 3/3 zum Spiel 4/4)


Techniktraining ist Sache der Studierenden.

Die individuelle Grundschulung wird mit Lernkontrollen überprüft (Kontrollblätter).

Alle ausgewählten Formen müssen als Lernkontrolle durchführbar sein.

**Lecture notes**

Lehrunterlagen können von der Homepage abgerufen werden.
Prerequisites / notice
Prüfungen Inhalte: Die Prüfungsinhalte werden während des Semesters erarbeitet und am Ende des Semesters online schriftlich zur Verfügung gestellt.

557-0542-01L Volleyball I
Prerequisite: Assessment Polysport passed (or Assessment I or II or III).

W 2 credits 2G M. Attinger, N. Beeler

Abstract
Acquire technical and tactical abilities in the game of volleyball

Objective
- Experience and use of various aspects of volleyball as a teamplayer

Content
- Techniques and tactics of indoor-volleyball (1:1 to 6:6)
- Various forms of warmups and tournament setups

Literature
"Volleyball, Training & Coaching", Czimek & DVV, 2017
"Volleyball spielen", Föster (BASPO), 2016
"Volleyball verstehen", Schnyder-Benoit (BASPO), 2016
"Kids Volley", Monnet et al (BASPO), 2016
"Volleyball Grundlagen" Papageorgiou/Spitzley 2005

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making fostered
- Problem-solving fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork assessed
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking fostered
- Critical Thinking fostered
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

557-0603-01L Snowsports I - Ski
Only for BSc / MSc HST / Teaching Diploma Sports
100% presence is required!
Registration via Study Administration necessary.
Compulsory for Teaching Diploma Sports.

W 2 credits 2G C. Elmiger-Schnyder, further lecturers

Abstract
Education in the disciplines of winter sports.
- J+S Education possibility
- Transfer Offpist
- Transfer Nordic Cross

Objective
The students:
- experience the different winter sports.
- gain an understanding of how to ski off-piste.
- Transfer: Input Nordic Cross!

Content
- To apply and vary personal technique of alpine skiing
- To acquire and vary personal technique of cross-country skiing
- Competition in ski-jumping, and giant slalom
- To gain an understanding in how to ski off-piste
- To gain Nordic Cross

557-0603-02L Snowsports I - Snowboard
Only for BSc / MSc HST / Teaching Diploma Sports
100% presence is required!
Registration via Study Administration HST necessary.
Compulsory for Teaching Diploma Sports.

W 2 credits 2G C. Elmiger-Schnyder, further lecturers

Abstract
Education in the disciplines of winter sports.
- J+S Education possibility
- Transfer Offpist
- Transfer Nordic Cross

Objective
The students:
- experience the different winter sports!
- Gain an understanding of how to ski off-piste!
- Gain an understanding of how to Nordic Cross.

Content
- To apply and vary personal technique of snowboarding
- To acquire and vary personal technique of cross-country skiing
- Competition in ski-jumping, and giant slalom
- To gain an understanding in how to ski off-piste
- To gain an understanding in how to Nordic Cross

In-depth Education

Number Title Type ECTS Hours Lecturers
557-0446-02L  Athletics II  W  2 credits  2G  C. Brozzo, further lecturers
Prerequisites: Athletics I attended.

Compulsory for Teaching Diploma Sports.
80% active participation required

Abstract
The athletics level 2 course focuses on methodological and didactic aspects of disciplines taught in the level 1 course. Pole vault is introduced as a new and additional discipline. Central elements required for passing the course don’t include skill assessments or athletic performance tests but rather didactical contributions.

Objective
The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Content
- Specific warm-up for athletics
- Core elements of all disciplines
- Acquiring of technical pole vault skills
- Learning how to support an athlete during pole vaulting
- Keys to a successful baton handoff
- Written assignment on a movement observation task
- How to modulate intensity with task variations
- Developing feedback skills

Lecture notes
No script

Literature
J+S Kernlehrmittel
J+S Broschüre Leichtathletik verstehen & Leichtathletik vermitteln
J+S Leichtathletik Manual Kinder und Jugendliche

Prerequisites / notice
It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Competencies
Subject-specific Competencies
Concepts and Theories  fostered
Method-specific Competencies
Analytical Competencies  fostered
Decision-making  fostered
Problem-solving  fostered
Social Competencies
Leadership and Responsibility  fostered
Personal Competencies
Self-awareness and Self-reflection  fostered

557-0449-00L  Athletics III  W  1 credit  1G  C. Brozzo, further lecturers
Prerequisites: Athletics I (557-0444-01L) attended.

Compulsory for Teaching Diploma Sports.
80% active participation required.

Abstract
Athletic skills will be trained in the course.
the course doesn’t include skill assessments or athletic performance tests.

Objective
Skills improvement in the athletic performance
It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Content
- Training in various track and field disciplines
- Group challenges

Lecture notes
No script

Literature
J+S Manual Kinder und Jugendliche
J+S Broschüre Turnen - Leichtathletik

Prerequisites / notice
It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Competencies
Subject-specific Competencies
Concepts and Theories  fostered
Method-specific Competencies
Problem-solving  fostered
Social Competencies
Cooperation and Teamwork  fostered
Personal Competencies
Self-awareness and Self-reflection  fostered
Self-direction and Self-management  fostered

557-0523-00L  Handball II  W  2 credits  2G  F. Lüchinger
Prerequisites: Handball I attended.

Compulsory for Teaching Diploma Sport.
80% active participation required.

Abstract
Recognizing and experiencing important aspects of the game and preparing them for your own lessons with the help of didactic-methodical concepts.

Objective
The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.
You will know and experience the most important aspects of teaching handball and prepare them for teaching with the help of didactic-methodical concepts.
You will know and experience different forms of assessment for the school.
You will improve your individual skills in technique and tactics.

Content
You will learn and discuss the didactic-methodological concepts to adapt exercises and the game in the sense of physical education and sport and to develop them further with a class.
You will learn and discuss different forms of assessment for the school.
You will improve your individual skills in technique and tactics.

Prerequisites / notice
It is not required to have passed the level I course, but it is mandatory to have attended it previously.
80% presence required.

557-0539-00L  Gymnastics / Acrobatics II  W  2 credits  2G  M.-M. Jäggi
Prerequisite: Attended basic education
- "Apparatus Gymnastics and Trampoline I" (557-0433-00L); and
- "Acrobatics I" (557-0432-01L).

Abstract

Objective

Content

Prerequisites / notice

It is not required to have passed the level I course, but it is mandatory to have attended it previously.
80% presence required.
Abstract

Acquirement and Application of classic as well as modern forms of movement on different apparatuses and on the trampoline
Application and Creation of established basic skills

Objective

The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously

The students should be able to:
- enhance their repertoire on apparatus specific movements
- deepen their existing store of movements......

Content

- further core movements and its combinations on different apparatuses
- handsprings and (free) somersaults back- and forwards, respectively twists back- and forwards on different apparatuses
- creative and cooperative composition in a threesome accompanied by music
- vault springs and touching down springs (stuetz springs) to overcome obstacles in an artful way (Freerunning)
- integrated theoretical coherences of the qualitative movement learning process
- conveyance of methodical and didactical principles as well as topic specific criteria
- functional warm-up with regard to specific contents

557-0544-00L  Floorball II  W  2 credits  2G  F. Ungrad

Prerequisite: Floorball I attended.
Compulsory for Teaching Diploma Sports.

80% active participation required.

Abstract

Learning the methodology and the didactics for teaching floorball and guiding floorball games at high school level.

Objective

The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Prerequisites / notice

80% presence required.

Competencies

Method-specific Competencies
Analytical Competencies
Personal Competencies
Decision-making
Self-awareness and Self-reflection
fostered
fostered
fostered

557-0602-00L  Badminton II  W  2 credits  2G  P. Lüscher Luchsinger

Prerequisite: Badminton I (557-0601-00L) attended.
Mandatory for Teaching Diploma Sports.

80% active participation required.

Abstract

In this course you will build up and experience different tactical and technical exercise forms for classes. At the same time you will be able to deepen your own badminton skills.

Objective

The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Content

In this course we work on possibilities to build up different tactical and technical exercise forms and structures for classes. You get to know a variety of games. You learn how you can diversify exercises – depending on the level and the age of your pupils.

Your own badminton skills will be deepened.

Prerequisites / notice

80% presence required.

Education Acquired Outside ETH

557-0450-00L  Life Saving Rescue Test Plus Pool SLRG  O  2 credits

Confirmation of course attendance Brevet Basis Pool and Brevet Plus Pool SLRG.

External education! Credit points only for Teaching Diploma Sports!

Abstract

Acquisition of “SLRG Brevet Plus Pool”.

Objective

Based on the Brevet Basic Pool, the Brevet Plus Pool provides you with skills to supervise groups in unguarded pools.

To recognize danger in, on and around water
Knowledge and handling of life saving equipment
Rescue and towing techniques
Orientation under water
To rescue a person
Basis knowledge in anatomy and first aid

Prerequisites / notice

Prerequisites: please consult www.slrg.ch

557-0451-00L  First Responder Level 2  O  2 credits

Confirmation of course attendance “First Responder Level 2 IVR”.

More information: www.samariter.ch

External education! Credit points only for Teaching Diploma Sports!

Abstract

Acquisition of the certificate “Ersthelfer Stufe II IVR”.

In this course you will acquire the basic knowledge related to safety and hygiene measures in case of injuries and acute illnesses.
Objective
- To be able to judge an injured person and to apply life saving actions
- To carry out wound treatment with actual bandage
- To list the characteristics of a sprain, strain, dislocation and to apply first-aid interventions
- To carry out fixed bandages with common material
- To explain the function of the cardiovascular system
- To name the symptoms of poisoning
- To list the signs of acute illness
- To put together the content of a first-aid box
- To carry out safety interventions in daily situations.

Content
* Hautverletzungen
* Wundinfektion / Blutvergiftung
* Stürze im Alltag (Verstauchungen, Prellungen, Quetschungen)
* Sportverletzungen, Knochenbrüche
* Herzkreislauftörungen
* Alltagskrankheiten in der Familie

Prerequisites / notice
Prerequisites: please consult www.samariter.ch

Compensation Courses

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>557-0603-01L</td>
<td>Snowsports I - Ski</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>C. Elmiger-Schnyder, further lecturers</td>
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<td></td>
<td>- Transfer Nordic Cross</td>
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<td>Content</td>
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<td>To gain Nordic Cross</td>
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| 557-0603-02L    | Snowsports I - Snowboard       | W    | 2    | 2G    | C. Elmiger-Schnyder, further lecturers |
|                 | Only for BSc / MSc HST / Teaching Diploma Sports |      |      |       |                         |
|                 | 100% presence is required!     |      |      |       |                         |
| Abstract        | Education in the disciplines of winter sports. |      |      |       |                         |
|                 | - J+S Education possibility    |      |      |       |                         |
|                 | - Transfer Offpist             |      |      |       |                         |
|                 | - Transfer Nordic Cross        |      |      |       |                         |
| Objective       | The students:                  |      |      |       |                         |
|                 | - experience the different winter sports! |      |      |       |                         |
|                 | - Gain an understanding of how to ski off-piste! |      |      |       |                         |
|                 | - Gain an understanding of how to Nordic Cross. |      |      |       |                         |
| Content         | To apply and vary personal technique of snowboarding |      |      |       |                         |
|                 | To acquire and vary personal technique of cross-country skiing |      |      |       |                         |
|                 | Competition in ski-jumping, and giant slalom |      |      |       |                         |
|                 | To gain an understanding in how to ski off-piste |      |      |       |                         |
|                 | To gain an understanding in how to Nordic Cross |      |      |       |                         |

| 557-0605-01L    | Snowsports II - Ski            | W    | 2    | 2G    | C. Elmiger-Schnyder, further lecturers |
|                 | Prerequisite: Basic course Snowsports I - Ski passed. |      |      |       |                         |
|                 | 100% presence is required!     |      |      |       |                         |
| Abstract        | Specialization training: Acquisitions of special skills, getting to know the performance factors and training methods in the areas of Snowsports. |      |      |       |                         |
| Objective       | Snow sports Skiing:            |      |      |       |                         |
|                 | - To deepen and expand experience and skills in snow sports and in the personal competency of technique of the chosen snow sport. |      |      |       |                         |
| Content         | Snow sports skiing:            |      |      |       |                         |
|                 | - General and specific education of personal competency in technique of the chosen snow sport. |      |      |       |                         |
| Prerequisites / notice | Requirement: Basic course in Snowsport I completed. |      |      |       |                         |

| 557-0605-02L    | Snowsports II - Snowboard      | W    | 2    | 2G    | C. Elmiger-Schnyder, further lecturers |
|                 | Prerequisite: Basic course Snowsports I - Snowboard passed. |      |      |       |                         |
|                 | 100% presence is required!     |      |      |       |                         |
| Abstract        | Specialization training: Acquisitions of special skills, getting to know the performance factors and training methods in the areas of Snowsports. |      |      |       |                         |
| Objective       | Snow sports (Snowboarding):    |      |      |       |                         |
|                 | - To deepen and expand experience and skills in snow sports and in the personal competency of technique of the chosen snow sport. |      |      |       |                         |
### Analytical Competencies

**Off-piste education:**
- Critical Thinking
- Understanding for the development and adaptation of sports from the ancient world to present times.

### Exercise Physiology

This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to

### Concepts and Theories

**Specialization training:** Acquisitions of special skills, getting to know the performance factors and training methods in the areas of

### Personal Competencies

**Method-specific Competencies**
- Analytical Competencies
  - fostered
- Critical Thinking
  - fostered

**Content**
- Snow sports:
  - To deepen and expand experience and skills in snow sports and in the personal competency of technique of the chosen snow sport.
  - To expand skills to the area of telemark

**Objective**
- Off-piste education:
  - Planning and realization of back-country skiing
  - Handling of the environment
  - Avalanche prophylaxis

**Prerequisites / notice**
- Requirement: Basic course in Snowsport I completed.

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### Additional Requirements in Sports Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-0203-00L</td>
<td>Movement and Sport Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>W. R. Taylor, R. List</td>
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<tr>
<td>376-0207-00L</td>
<td>Exercise Physiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>C. Spengler, F. Gabe Beltrami</td>
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<tr>
<td>376-1033-00L</td>
<td>History of Sports</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Gisler</td>
</tr>
</tbody>
</table>

**Objective**
- They analyse and describe human movement according to the laws of mechanics.

**Abstract**
- Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

**Content**
- Movement and sport biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

**Lecture notes**
- Is available within the Moodle

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories
    - assessed
- Method-specific Competencies
  - Techniques and Technologies
    - fostered
  - Analytical Competencies
    - fostered
- Personal Competencies
  - Critical Thinking
    - fostered

**Objective**
- Movement and sport biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

**Abstract**
- This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interactions of the different systems influencing factors, e.g. genetics, gender, age, altitude/depth, heat/cold, with respect to performance and health.

**Content**
- The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/depth, heat and cold on the named factors.

**Lecture notes**
- Online material is provided during the course.

**Literature**
- Wird in der Vorlesung bekannt gegeben.

**Prerequisites / notice**
- Anatomy and Physiology I + II

---

### Content

**Snow sports (snowboarding):**
- General and specific education of personal competency in technique of the chosen snow sport: Park, Piste and Off-Piste

**Prerequisites / notice**
- Requirement: Basic course in Snowsport I completed.

---

### Registration via Study Administration necessary.

#### Abstract

Specialization training: Acquisitions of special skills, getting to know the performance factors and training methods in the areas of Snowsports.

**Objective**
- Off-piste education:
  - Planning and realization of back-country skiing
  - Handling of the environment
  - Avalanche prophylaxis

**Content**
- Snow sports:
  - General and specific education of personal competency in technique of the chosen snow sport.
  - Telemark as an extra experience in the framework of technique on slope, park and off-piste.

**Prerequisites / notice**
- Requirement: Basic course in Snowsport I completed.

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### Additional Requirements in Sports Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>376-0203-00L</td>
<td>Movement and Sport Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>W. R. Taylor, R. List</td>
</tr>
<tr>
<td>376-0207-00L</td>
<td>Exercise Physiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>C. Spengler, F. Gabe Beltrami</td>
</tr>
<tr>
<td>376-1033-00L</td>
<td>History of Sports</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Gisler</td>
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</table>
376-1107-00L  
**Sport Pedagogy**  
**W** 2 credits 2V  
C. Herrmann

**Abstract**  
The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the pedagogical-psychological competences for the optimisation of future teaching activities. These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives assessed.

**Objective**  
Development of pedagogical-psychological competences for the optimisation of future teaching activities.

**Content**  
- Subject area of educational psychology  
- Motivating students in physical education  
- Building self-efficacy and strengthen the self-concept  
- Promoting positive emotions and a positive attitude to anxiety  
- Encouraging self-directed learning  
- Leading classes and promoting cooperation  
- Communicating with students efficiently  
- Reflecting your own expectations critically  
- Handling gender issues sensitively  
- Promoting inclusion / Strengthening social and moral development  
- Dealing with difficult students  
- Evaluating achievements of students

**Literature**  

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376-1117-00L  
**Sport Psychology**  
**W** 2 credits 2V  
H. Gubelmann

**Abstract**  
This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.

**Objective**  
Students are given insight into different work areas of sport psychology. In order to understand what the sport psychology is, it is necessary to explain the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students’ expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.

**Content**  
Main Topics  
- Introduction to sport psychology  
- Cognitions in sports: mental rehearsal and mental training  
- Emotions and stress  
- Motivation: goal-setting in sports  
- Career and career transition in elite sport  
- Coach-Athlete-Interaction  
- Psychological aspects of sport-injury rehabilitation  
- Group dynamics in sport

**Literature**  

---

376-1127-00L  
**Sociology of Sport**  
**W** 2 credits 2V  
R. Bürgi

**Abstract**  
These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.

**Objective**  
The lectures set out to:  
- present the different dimensions, functions and interrelationships of present-day sport  
- provide an introduction to the central theories and models of (sport) sociology  
- show how far sport reflects society and how it changes and becomes more differentiated in the process  
- take current examples to highlight the sociological view of sport.

**Content**  
Sport and social change: developments and trends  
The economy and the media: commercialisation, logic, dependencies  
Social inequalities and distinctions: social impact, health and sport, sport and gender  
Conflicts and politics: sports organizations, doping, violence

**Literature**  

A detailed program with additional references will be delivered at the beginning of the lecture.

**Competencies**  
- Subject-specific Competencies: Concepts and Theories  
- Method-specific Competencies: Analytical Competencies  
- Social Competencies: Sensitivity to Diversity  
- Personal Competencies: Critical Thinking

---

376-0130-00L  
**Laboratory Course in Exercise Physiology**  
**W** 4 credits 4P  
C. Spengler

**Abstract**  
Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.

**Objective**  
Gain hands-on experience in exercise physiology and consolidate knowledge on physiological adaptations to different types and degrees of physical activity and climatic influences. Learn fundamental assessment techniques of the muscular system, the cardio-respiratory system and of whole-body performance, learn scientifically correct data analysis and interpretation of results. Insight into today's Sports Medicine.
Critical Appraisal of Evidence for Exercise in Health

**Abstract**
This course will discuss the mechanisms and latest evidence-based recommendations of physical activity and exercise for a series of conditions and populations. In the second part of each lecture session, published randomized controlled trials of the respective lecture’s topic will be discussed and critically appraised based on established tools.

**Objective**
On completion of this course students will be able to:
1. understand the role of physical activity and sedentary behavior in the maintenance of health and the etiology, prevention and treatment of disease
2. synthesize effective physical activity and exercise interventions for the prevention and management of several diseases and populations
3. evaluate recent evidence regarding physical activity and exercise interventions

**Content**
New trends in physical activity for prevention and rehabilitation
Introduction to critical appraisal tools
Exercise for Cancer Rehabilitation
Exercise for Musculoskeletal Rehabilitation (Focus on Osteoarthritis and Low Back Pain)
Exercise in Parkinson’s disease
Exercise for Rehabilitation of Metabolic Disorders (Focus on Obesity and Diabetes type 2)
Exercise for age-related diseases and disorders, Part A (Focus on Frailty and Falls)
Exercise for Stroke Rehabilitation
Exercise in Dementia and Mild Cognitive Impairment
Exercise for Children’s Rehabilitation (focus on Cerebral Palsy)
Exercise for age-related diseases and disorders, Part B (Focus on Sarcopenia and Osteoporosis)
Exercise in Multiple Sclerosis
Exercise for Cardiovascular Rehabilitation (Focus on Heart Failure)

**Literature**

**Competencies**
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Techniques and Technologies fostered
- Personal Competencies: Critical Thinking assessed

**376-0225-00L**

**Clinical and Movement Biomechanics**

**Abstract**
Measurement and modeling of the human movement during daily activities and in a clinical environment.

**Objective**
The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with regards to human movement.

**Content**
This course includes study design, measurement techniques, clinical testing, accessing movement data and analysis as well as modeling

**Literature**
- Conconi-Tests, Determination of anaerobic threshold, Cooper-Test, 1-repetition maximum test, lactate minimum test, dynamometry, mechanography, body composition etc.). Insight into measurements in Sports Medicine.

**Prerequisites / notice**
- Prerequisite: Anatomy and physiology classes and lab course in physiology successfully completed (BWS students please contact C. M. Spengler)

**Desirable:**
- Exercise Physiology Lecture (concomitantly or passed; is selection criterion in case of more applications than lab spaces)

**376-1651-00L**

**Nutrition and Performance**

**Abstract**
The course introduces basic concepts of the interaction between nutrition and exercise performance.

**Objective**
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

**Content**
The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

**Literature**
- Lecture slides and required handouts will be available on the ETH website (moodle).
- Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

**Prerequisites / notice**
- General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

**The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).**
Objective
The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

Content
The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students - each one will focus on one of the following research topics:

- Topic 1: Molecular pathways that control muscle stem cell self-renewal and differentiation
- Topic 2: Genome engineering to correct genetic mutations that cause muscle diseases
- Topic 3: Muscle fiber composition, force production and insulin sensitivity
- Topic 4: Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session.

For the journal club, each group of students will receive a peer-review article that is highly relevant to the respective group’s research topic. Each of the 4 groups will present and discuss the article in a journal club format to the rest of the participants the following week. During the four practical sessions, students will gain hands-on experiences and learn different lab techniques related to molecular biology of exercise and muscle regeneration. Each group will be presented with a research objective that is related to their topic, and perform in collaboration with teaching assistants a set of experiments that aim to address the research objective. At the final evaluation session, each group of students will present their results and identify follow-up research questions and hypothesis based on their experimental achievements.

Select practical methods that the proposed course will teach include:

i. Group 1: tissue culture, isolation of muscle stem cells via FACS, differentiation of muscle stem cell into muscle fibers, small molecules screens, quantitative analysis of muscle cell proliferation and fusion, Immunofluorescence.

ii. Group 2: tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crisp-Cas9 gene editing of genetic mutations that cause muscle diseases in muscle stem cells and fibers, Immunofluorescence and PCR.

iii. Group 3: ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, immunofluorescence and western blot.

iv. Group 4: tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers, Western blot.

Prerequisites / notice
Prerequisites:
376-0006-02L Laboratory Course in Molecular biology

Sport Teaching Diploma - Key for Type
| W+ | Eligible for credits and recommended |
| W  | Eligible for credits |
| O  | Compulsory |
| E- | Recommended, not eligible for credits |
| Z  | Courses outside the curriculum |
| Dr | Suitable for doctorate |

Key for Hours
- V lecture
- G lecture with exercise
- U exercise
- S seminar
- K colloquium
- P practical/laboratory course
- A independent project
- D diploma thesis
- R revision course / private study

ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
Public Policy Bachelor

1. Semester

Core Courses First Year Examinations

Examination Block 1

Students are free to take the exam either in German or in French. They may choose between 853-0723-00L 'Introduction to Torts, Contract and Insurance Law' or 851-0709-00L 'Introduction to Civil Law' (French)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>853-0723-00L</td>
<td>Introduction to Torts, Contracts and Insurance Law</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>C. von Zedtwitz</td>
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<tr>
<td></td>
<td>Introduction to Torts, Contracts and Insurance Law.</td>
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<tr>
<td></td>
<td>The course shall make sure that the participants are fit to make the adequate decisions when encountering legal questions and issues in their career.</td>
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<td>In order to achieve this goal, legal problems and issues will be presented to the participants and then discussed in class.</td>
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<td>The course touches upon relevant topics of Contract Law (formation of contract and contract performance), Tort Law (including liability limitation), corporate law (types of corporations, formation of LLC), civil procedure (jurisdiction and applicable law, costs, when and how to engage a lawyer) and insurance law (duty to disclose relevant facts, gross negligence).</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course 'Introduction au Droit civil' (851-0709-00) provides an introduction to the law of Contracts and Torts in French.</td>
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<tbody>
<tr>
<td>851-0709-00L</td>
<td>Introduction to Civil Law</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>H. Peter</td>
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<tr>
<td></td>
<td>The course Private Law focuses on the Swiss Code of Obligations (contracts, torts) and on Property Law (ownership, mortgage and easements). In addition, the course will provide a short overview of Civil Procedure and Enforcement.</td>
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<td>Teaching of the principles of law, particularly private law. Introduction to law.</td>
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<td>Le cours de droit civil porte notamment sur le droit des obligations (droit des contrats et responsabilité civile) et sur les droits réels (propriété, gages et servitudes). De plus, il est donné un bref aperçu du droit de la procédure et de l'exécution forcée.</td>
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<tr>
<td>Literature</td>
<td>Edition officielles récentes des lois fédérales, en langue française (Code civil et Code des obligations) ou italienne (Codice civile e Codice delle obbligazioni), disponibles auprès de la plupart des librairies.</td>
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<td>Sont indispensables:</td>
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<td>- le Code civil et le Code des obligations;</td>
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<tr>
<td></td>
<td>- Nef, Urs Ch.: Le droit des obligations à l'usage des ingénieurs et des architectes, trad. Bovay, J., éd. Payot, Lausanne</td>
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<td>- Boillod, J.-P.: Manuel de droit, éd Slatkine, Genève</td>
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<td>- Le cours de droit civil et le cours de droit public (2e sem.) sont l'équivalent des cours &quot;Recht I&quot; et &quot;Recht II&quot; en langue allemande et des exercices y relatifs.</td>
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<td>- Les examens peuvent se faire en français ou en italien.</td>
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<td>- Examen au 1er propédeutique; convient pour travail de semestre.</td>
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<td>- Con riassunti in italiano. E possibile sostenere l'esame in italiano.</td>
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<tr>
<td>851-0577-00L</td>
<td>Principles of Political Science</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>T. Bernauer, C. Brügge, S. Rhein</td>
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<tr>
<td></td>
<td>This course deals with basic questions, concepts, theories, methods, and empirical findings of political science.</td>
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<tr>
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</tbody>
</table>

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2340 of 2667
Der Kurs findet vor Ort statt und wird weder online gestreamt noch aufgezeichnet.


Der Kurs besteht aus

- einem ersten Teil, der jeweils am Montag, ab 25. September 2023, wöchentlich bis und mit 18. Dezember 2023, 10:15-12:00, vor Ort auf dem Campus stattfindet (LEE E 101, Leonhardstrasse 21)


Die 5. Auflage dieses Lehrbuches ist via Buchhandlungen oder online erhältlich. Übungsfragen und ein Glossar finden Sie hier: https://ib.ethz.ch/teaching/pwgrundlagen.html

Vor der Sitzung:
2. Durch eine kurze (digitale) Umfrage in Moodle werden Übungsfragen ermittelt, welche von den Studierenden als besonders schwierig erachtet werden und die deshalb im Übungsteil (jeweils 12:15 – 13:00) vertieft besprochen werden.

Der Ablauf der Sitzungen ist dann meist wie folgt:
1. Teil: Wir behandeln Übungsfragen, die per Umfrage als besonders schwierig identifiziert wurden.
2. Teil: Wir behandeln Übungsfragen, die per Umfrage als besonders schwierig identifiziert wurden.


Die 5. Auflage dieses Lehrbuches ist via Buchhandlungen oder online erhältlich. Übungsfragen und ein Glossar finden Sie hier: https://ib.ethz.ch/teaching/pwgrundlagen.html

Literature

Die 5. Auflage dieses Lehrbuches ist via Buchhandlungen oder online erhältlich. Übungsfragen und ein Glossar finden Sie hier: https://ib.ethz.ch/teaching/pwgrundlagen.html

Prerequisites / notice
Siehe Syllabus im Moodle

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Concepts and Theories</th>
<th>Analytical Competencies</th>
<th>Problem-solving</th>
<th>Communication</th>
<th>Cooperation and Teamwork</th>
<th>Self-presentation and Social Influence</th>
<th>Sensitivity to Diversity</th>
<th>Negotiation</th>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
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853-0033-00L Leadership I  O 3 credits  2V  I. Igic

Abstract
The lectures "Leadership I" (WS) and "Leadership II" (SS) have been designed as a two-semester lecture series, but may also be followed independently of one another or in reverse order. "Leadership I" covers the following fields: leadership basics, leadership theories and leadership styles, the concept of leadership responsibility and the role of communication in practical leadership.

Objective
The aim of this lecture is to give students an introductory overview of relevant topics regarding leadership research and practice, thus enabling them to gain a deeper understanding of the leadership phenomenon. Students should understand different concepts of leadership in the complex interaction between individuals, groups, organization, contexts, and situations. They should grasp the concept of leadership responsibility (leadership ethics) and be able to derive consequences for leadership in practical situations. They should recognize the fundamental importance of communication in leadership situations and receive input that enables them to communicate adequately in specific situations.
Competencies

**Subject-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

**Method-specific Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

**Social Competencies**

- Decision-making
- Problem-solving
- Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

**Personal Competencies**

- Decision-making
- Problem-solving
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Examination Block 2**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>351-1034-00L</td>
<td>Microeconomics <a href="#"></a> Not for students belonging to D-MTEC!</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>A. Fetz, M. Gysler</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to the economic decisions of households and firms, and their coordination through markets. Analysis of different market structures and of situations in which markets may lead to socially undesirable outcomes.

**Objective**

Understanding of basic microeconomic models. Ability to apply these models to real world economic situations.

**Content**

Economics as a science, division of labour and welfare (concept of comparative advantage), supply and demand (market equilibrium, elasticity), households (preferences, demand), firms (technology, cost analysis, profit maximisation, supply), perfect competition, monopoly and oligopoly, externalities, public goods, information, factor markets and income distribution

**Lecture notes**

via email

**Literature**

Mankiw, G. and Taylor M. (2023): Economics, Cengage Learning

**Prerequisites / notice**

Course macroeconomics in the spring term

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Media and Digital Technologies
- Project Management
- Self-presentation and Social Influence
- Sensitivity to Diversity

**Method-specific Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Social Competencies**

- Decision-making
- Problem-solving
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Personal Competencies**

- Decision-making
- Problem-solving
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>853-0725-00L</td>
<td>History Part One: Europe (The Cradle of Modernity,</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>H. Fischer-Tiné</td>
</tr>
</tbody>
</table>

**Abstract**

A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture series looks at several key aspects of these modernization processes and ask about their continuing relevance for our times . The regional focus lies on the Britain, where these processes took place for the first time.

**Objective**

At the end of this lecture course, students can: (a) highlight the most important changes in the "long nineteenth century" in Britain (b) explain their long-term effects (also for other European countries ; and (c) relate these changes to global developments today.

**Content**

The thematic foci include: Industrialization, urban growth, democratisation and mass politics, shifting gender roles and ideals, and the emergence of consumerism and leisure culture.

**Lecture notes**

Power Point Slides and references will be made available in digital form during the course of the semester.

**Literature**

Mandatory and further reading will be listed on the course plan that is made available as from the first session.

**Prerequisites / notice**

This lecture series does not build upon specific previous knowledge by the students.

**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Media and Digital Technologies
- Project Management
- Self-presentation and Social Influence
- Sensitivity to Diversity

**Method-specific Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Social Competencies**

- Decision-making
- Problem-solving
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Personal Competencies**

- Decision-making
- Problem-solving
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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<th>Lecturers</th>
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<tbody>
<tr>
<td>853-0037-00L</td>
<td>Military Psychology and Pedagogy I</td>
<td>O</td>
<td>4</td>
<td>2V+3U</td>
<td>H. Annen</td>
</tr>
</tbody>
</table>

**Abstract**

Examine the fundamentals of the two sciences and establish links with military life. Discuss various schools of thought in psychology and focus on content and process theories of motivation. Explore characteristics of pedagogical thinking and discuss the values of military education with reference to the young adult serving in the armed forces.
Objective
- Becoming acquainted with basic psychological views of human behaviour and experience
- Knowing content- and process theories of motivation and being able to transfer them to the military context
- Knowing the possibilities and limitations of military education and deriving consequences

Content
Overall, the objective is to become acquainted with the basics of both scientific areas and to make references to military practice. Military psychology is a branch of applied psychology, consequently selected aspects of psychological principles will be covered. Military pedagogy hasn't yet established itself firmly as an independent scientific discipline, it nevertheless can draw on a deep-seated tradition in Switzerland. Thus, the great importance that has been attached to the discussion of education in Swiss society and academia will be taken into account.

Subjects:
- History of military psychology
- Introduction to psychological thinking
- Motivational theories
- Defence-, service-, operational- and combat motivation
- Swiss military pedagogy
- Education as defining feature of pedagogic thinking and acting

This course is completed by a compulsory one week course between terms.

Literature
- Annen, H., Steiger, R. & Zwygart, U.: Gemeinsam zum Ziel, Huber, Frauenfeld 2004 (provided as pdf)
- Stadelmann, J.: Führung unter Belastung, Huber, Frauenfeld 1998 (provided as pdf)

The lecture is supported by a virtual learning environment containing relevant documents (presentations and texts) and information to further literature.

Competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Assessments
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Social Competencies
  - Leadership and Responsibility
  - Self-presentation and Social Influence
- Personal Competencies
  - Critical Thinking
  - Self-awareness and Self-reflection

Remainig Core Courses of the Bachelor Programme

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>853-0205-00L</td>
<td>Proseminar I: Political Methodology</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>A. Levis, E. Henninger</td>
</tr>
</tbody>
</table>

Abstract
Teaching of formal requirements of scientific work (philosophy of science with a focus on the social sciences); literature reviews and the basics of conducting independent research on short as well as simple topics; basics of conceptualizing research designs for politically relevant questions and hypotheses.

Objective
1) Understanding the goal and the basic procedures of (empirical social sciences) scientific work (philosophy of science, theory building, research design, as well as the correct employment of sources, data and literature).
2) Identification of relevant research questions.
3) Creating a common basis for a thorough and systematic analysis of these.

Content
Political Methodology I seeks to introduce students to the basics of scientific work and procedures in the social sciences, which in turn shall allow them - also in conjunction with Political Methodology II - to conduct work that fulfills satisfactory standards of research quality throughout their further studies.

With regard to Political Methodology I, this seminar primarily focuses on the philosophy and theory of (empirical social) sciences, its structure, and procedures. The seminar emphasizes substantive contents and ways of presenting them, research and, conceptual work. Additionally, it deals with the basis of establishing research designs with politically relevant questions and hypotheses.

Literature

Prerequisites / notice
Each student will be graded by two exercises (50% each).
1) Source analysis and acquisition: based upon a research question that will be given by the lecturer, the student shall collect a comprehensive list of the relevant literature and summarize that with her/his own words.
2) Critical analysis of sources: based upon a research article that the student chooses on her/his own, the student shall write a critical analysis of that, which mirrors frame and structure of scientific writing

Submission dates will be communicated in the first meeting.

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>853-0064-00L</td>
<td>Military Sociology I</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>T. Szvircsev Tresch, S. De Rosa, T. Ferst</td>
</tr>
</tbody>
</table>

Abstract
Beside of the most important terms of sociology, demographic changes and the related value and structure change will be analysed. The second part focuses on organizational sociology. Thirdly, the course examines to which extent armed forces can be considered as organizations like any other and to which extent they constitute a special case from an organizational and normative point of view.

Objective
Recognize and explain current changes (social change) in modern society (individualisation, pluralisation); describe demographic changes in Switzerland; explain the structures of societies; define issues and fields of research in modern military sociology and explain the foundations of organisational sociology; explain the military in terms of organisational sociology and identify specific traits of the military as an organisation.

Content
Societal change; organizations as societal phenomena; aims, structures, environments of organizations; specifics of the military as an organization; impacts of technological and societal changes on the armed forces in modern societies.

Literature
A reader with a set of texts will be handed out.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity assessed
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered

Languages

First Foreign Language

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<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>853-0405-00L</td>
<td>English, Part I</td>
<td>O</td>
<td>3</td>
<td>4G</td>
<td>S. Schweizer</td>
</tr>
</tbody>
</table>

Abstract
Teaching is focused on the acquisition of general English in the four classical skills, i.e. speaking, listening comprehension, reading comprehension and writing. The goal is to reach level B2 or C1 depending on the linguistic proficiency of the students.

Objective
This three-semester English course should enable the participants to successfully use the English language in an international military setting.

Content
Read, analyse and write military and civilian documents
Listening comprehension using current radio or TV reports
Practise speaking through group discussions and short presentations
Systematic revision and extension of key grammar points
Systematic acquisition of general and military vocabulary

Social Competencies

Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity assessed
Negotiation fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management fostered

3. Semester

 Remaining Core Courses of the Bachelor Programme

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>853-0015-00L</td>
<td>Conflict Research I: Political Violence</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>A. Juon</td>
</tr>
</tbody>
</table>

Abstract
Introduction to research on political violence in domestic and international politics. This course covers the causes and solutions to different types of political violence including interstate wars, civil wars, terrorism or social protests.

Objective
Knowledge on different types of political violence and their causes.

Content
This course offers an introduction to research on the causes and solutions to political violence in domestic and international politics. First, we discuss the definitions and concepts used in conflict research, the data and methods commonly applied and their historical development. Second, we focus on interstate wars and examine in this context state formation, nationalism and democracy. The third part of the course focuses on different types of political violence, including civil war, terrorism or social protests.

Prerequisites / notice
The course «Conflict Research II» in the following semester further examines civil wars.

Exercises complete the lectures, where the literature will be further discussed. The participants write a short memo (max. 3 pages) about one of the required readings.

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<tbody>
<tr>
<td>853-0047-00L</td>
<td>World Politics Since 1945: The History of International Relations</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>A. Wenger</td>
</tr>
</tbody>
</table>

Abstract
This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91; the focus here is on current issues in international security policy.

Objective
By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations since the end of the Second World War.

Content
cf. “Diploma Supplement”

Prerequisites / notice
The lecture is being supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch)

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Method-specific Competencies
Leadership and Responsibility fostered
Sensitivity to Diversity fostered
Negotiation assessed

Social Competencies
Communication fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered

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<tbody>
<tr>
<td>853-0065-00L</td>
<td>Business Administration I</td>
<td>O</td>
<td>4</td>
<td>3V</td>
<td>P. Barmettler</td>
</tr>
</tbody>
</table>

Abstract
The course BA I provides an understanding of the principles of General Business Management. It comprises an introduction to the basic business principles within a business acumen with a clear focus on value creation.

The theory conveyed is illustrated with exercises, case studies and examples from business practice.
Objectives

- Understanding and application of instruments and methods of general management.
- Driving customer equity.
- Reflection of common business practices.

Content

I ENTREPRENEURIAL THINKING AND ACTION

1. Customer orientation and value creation
2. Business and Environment

II BUSINESS PROCESSES

3. Legal forms of business under Swiss corporate law
4. Marketing I
5. Marketing II

III SUPPORTING PROCESSES

6. Human Resource Management I
7. Human Resource Management II
8. Organisation
9. Value-based management
10. Mission, Business Norms and Business Culture

IV MANAGEMENT PROCESSES

11. Strategic Management
12. Strategic Management and Business Culture

Literature


Content

Abstract

The lecture outlines the development of the armed forces (in terms of technology, armament and manpower) and the evolution of warfare and military history in the 19th and 20th centuries. It aims to help students understand military history as a subject and to analyze the evolution of armed forces and warfare in the context of socio-economic changes.

Objective

- Distinguish between military history as a subject and historiography as a way of describing events;
- Analyse the modern developments regarding armed forces and warfare in the context of socio-economic changes;
- Based on the approach regarding the revolution in military affairs, describe the evolution of the armed forces and of warfare;
- Exemplify the issues regarding the evolution of combat (First and Second World War, Vietnam War and Algerian War).

Content

The lecture examines the bases of the science of (military) history. It focuses on how military history developed from war history, on specific similarities and differences between military history and general historiography, the different ways of dealing with history in Switzerland, Germany, France and the Anglo-Saxon cultural area (different approaches), and on institutions which deal with military history such as universities, military academies, national and international commissions and associations, etc.

The lecture proceeds along the lines of the concept of "Military Revolution" and starts with the formation of modern European armed forces after the Fronde in the 17th century.

Based on the "Military Revolution" approach, the lecture examines the structural changes regarding the armed forces and the development of warfare from the 18th to the 20th century. Special emphasis will be put on how the battlefield was revolutionized due to the Napoleonic Wars, the industrialization in the 19th century, the First World War, the mechanization and totalization during the Second World War and the period of the Cold War.

Literature


Competencies

Subject-specific Competencies

- Concepts and Theories

Method-specific Competencies

- Analytical Competencies
  - fostered
- Social Competencies
  - fostered

Personal Competencies

- Critical Thinking
  - fostered
- Self-direction and Self-management
  - fostered

853-0063-00L

Strategic Studies I

Abstract

The lecture Strategic Studies deals with the use of political and military power from an interdisciplinary and global perspective.

Objective

Participants know how the understanding of strategy has changed over time. They understand the interplay between the basic components of strategy. They know the main strategic concepts and models and are able to discuss them critically. By examining selected historical and contemporary examples, they are aware of the inherent tension between the formulation (declaration) and implementation (application) of strategies. They are able to critically analyse original texts and contemporary publications in the field of strategic studies.

They are able to use case studies to explain how technological change affects strategic thinking.

Content

The two-semester course covers key issues in strategic studies. The first semester focuses on key concepts and foundations, which are applied and critically discussed in the second semester. The focus will be on the impact and practical implementation. A preparatory reading week will be organized.

Competencies

- Subject-specific Competencies
  - Concepts and Theories

- Method-specific Competencies
  - Analytical Competencies
  - fostered

- Social Competencies
  - fostered

- Personal Competencies
  - Critical Thinking
  - fostered
  - Self-direction and Self-management
  - fostered

853-0063-00L

Military History I

Abstract

The lecture outlines the development of the armed forces (in terms of technology, armament and manpower) and the evolution of warfare in the 19th and 20th centuries. It aims to help students understand military history as a subject and to analyze the evolution of armed forces and warfare in the context of socio-economic changes.

Objective

- Distinguish between military history as a subject and historiography as a way of describing events;
- Analyse the modern developments regarding armed forces and warfare in the context of socio-economic changes;
- Based on the approach regarding the revolution in military affairs, describe the evolution of the armed forces and of warfare;
- Exemplify the issues regarding the evolution of combat (First and Second World War, Vietnam War and Algerian War).

Content

The lecture examines the bases of the science of (military) history. It focuses on how military history developed from war history, on specific similarities and differences between military history and general historiography, the different ways of dealing with history in Switzerland, Germany, France and the Anglo-Saxon cultural area (different approaches), and on institutions which deal with military history such as universities, military academies, national and international commissions and associations, etc.

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Literature

Literature


Prerequisites / notice

The lecture is held in German.

Passive knowledge of English and French are required.

Competencies

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<th>Methods-specific Competencies</th>
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<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Sensitivity to Diversity</td>
<td>Critical Thinking</td>
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<tr>
<td>Critical Thinking</td>
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Prerequisites / notice

Literatur wird über Moodle bereitgestellt. Die Leistungskontrolle findet durch eine Seminarpräsentation und einen schriftlichen Schlussstest statt.

Competencies:

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Prerequisites / notice

853-0302-00L European Integration O 4 credits 1U+2S C. Freudlsperger

Abstract

Switzerland in the context of European integration

The course (lecture and tutorial) deals with the theory, development and central policy areas of European integration as well as the structures and processes of the EU as a political system. The course systematically links this basic knowledge with an analysis of the bilateral relationship between Switzerland and the EU.

Objective

The idea that Switzerland's relationship with the EU is at a 'crossroads' is a cliché that has been used repeatedly in recent decades. But could it be true this time? Since the breakdown of the negotiations on a framework agreement and the recently launched attempt for a third package of bilateral treaties, there is more uncertainty than ever in the Swiss-EU relationship. Switzerland is once again faced with the decision between greater proximity or isolation.

The seminar places the bilateral relationship between Switzerland and the EU in the broader context of European integration. It helps to understand the EU as a highly developed instrument of transnational problem solving and as a special political system. It provides basic knowledge about the history, institutions, procedures and policy areas of the EU and offers an introduction to important approaches in integration theory and political science analyses of European integration. The seminar systematically links this basic knowledge of the political system of the EU with an examination of the logic, development and perspective of the bilateral relationship between the EU and Switzerland.

Content

Course plan
1. A brief history of European integration
2. The European Union as a political system
3. The European Union as a community of law
4. The European Union as a system of differentiated integration
5. Theories of integration: Why integration?
6. Ten years of polycrisis: What next for the EU?
7. A brief history of the relationship between Switzerland and the EU
8. Trade
9. Free movement of persons
10. Justice and home affairs, foreign affairs, migration
11. Research, cohesion, energy
12. Domestic political discourse and public opinion in Switzerland
13. The future of Switzerland-EU relations

853-0101-02L Defense Economics I O 3 credits 2V M. M. Keupp, M. Bader, F. Muhly, C. Schulze

Abstract

In terms of structure and content, the event follows the lecturer's book "Militärökonomie" (Military Economics), which is available in two language versions:

- German language: ISBN 978-3-658-06146-3

Objective

* Recognizing parallels and contrasts between business and military thinking;
* Recognize and analyze planned economic systems;
* Understand the link between institutions, human action and economic results.
Content
The semester program of the course is divided into 14 modules of 90 minutes each, which combine lecture (teaching of analytical techniques) and exercise (application by means of concrete case studies).

The contents correspond to sections 1 to 2.2.5 of the above book. The following will be discussed:

1. fundamental military economic problems including historical introduction to the topic
2. the institutional foundations of a military organisation
3. the modern military as a planned economy system
4. actors and stakeholders in the system

Lecture notes
Lecture slides are given to the participants before the first lecture. In addition, the above mentioned book will be handed over to the participants. Participants of the lecture who are not professional officer candidates are requested to obtain the book from the library or bookstore.

Literature
ISBN 978-3-658-06146-3

ISBN 978-3-658-25287-8

Prerequisites / notice
none.

Competencies

| Subject-specific Competencies | Concepts and Theories | assessed
| Techniques and Technologies | fostered
| Analytical Competencies | assessed
| Decision-making | assessed
| Media and Digital Technologies | fostered
| Problem-solving | assessed
| Project Management | fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility assessed
Self-presentation and Social Influence fostered
Sensitivity to Diversity assessed
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Languages
First Foreign Language

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
853-0416-00L | English, Part III | O | 3 credits | 4G | S. Schweizer

Abstract
The knowledge and skills acquired in the second semester serve as a basis for further improvements in the areas of speaking, listening, reading and writing, which will enable students to enroll for the Cambridge exams. The goal is to reach Council of Europe (CEFR) level C1 or C2 depending on the linguistic proficiency of the students.

Objective
This three-semester English course should enable the participants to successfully use the English language in an international military setting.

Content
Read, analyse and write military and civilian documents
Listening comprehension using current radio or TV reports
Practise speaking with group discussions and short presentations
Systematic revision and extension of key grammar points
Systematic acquisition of general and military vocabulary

5. Semester
Remaining Core Courses of the Bachelor's Programme

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
853-0049-00L | Introduction to Constitutional Law in Security Policy | O | 3 credits | 2V | R. Müller

Abstract
The lecture deals with questions of competence and the security policy instruments in the federal state, conveys the basic principles of police law and deals with the management of extraordinary situations. Special topics are the army, civil protection, the intelligence service, cooperation (at home and abroad), the legal status of army members and private security providers.

Objective
The students can
- explain the basic concepts of security law;
- outline the basic constitutional order for Swiss security policy, identify the competences of the Confederation and assess the advantages and disadvantages of this basic order;
- explain and evaluate special legal forms of action;
- distinguish the tasks of security policy actors and assess forms of cooperation;
- derive legal limitations for operations of the armed forces from the Federal Constitution;
- identify the basic principles and individual special aspects of military-civilian cooperation;
- identify the police powers of the armed forces and determine the permissibility of using forms of coercion;
- describe the legal status of members of the armed forces and explain the special responsibility of officers;
- establish the relationship between the actions of state actors and the guarantee of fundamental rights;
- assess current challenges in security law.
Content

The lecture consists of three parts: Basics, Security policy instruments, Consolidation.

In the first part, terms of security and police law are introduced, the Swiss security constitution (Confederation and cantons) is explained and the significance of fundamental rights guarantees is shown.

In the second part, the security policy instruments of the Confederation and the cantons are assessed critically. A special focus is placed on the army. In addition to its constitutional anchoring and its tasks, the forms of deployment enshrined in the relevant regulations (e.g. military act) are examined from a legal perspective. Special attention is given to police powers of military forces.

The third part of the course deals in greater depth with the intelligence service, civil protection, the legal permitted tasks of private security providers and the legal status of military personnel.

The last part of the course is the examination.

Self-direction and Self-management

Cooperation and Teamwork

Problem-solving

Media and Digital Technologies

Decision-making

Creative Thinking

Integrity and Work Ethics

Adaptability and Flexibility

Communication

Cooperation and Teamwork

Self-awareness and Self-reflection

Critical Thinking

Self-direction and Self-management

Adaptability and Flexibility

Communication

Analytical Competencies

Leadership and Responsibility

Critical Thinking

Other texts are prepared in a reader.

853-0038-00L Swiss Foreign Policy

Abstract

This course analyzes the foundations and challenges of Swiss foreign policy. After reviewing the history of foreign policy conceptions since the early 20th century, we will discuss the determining factors of Swiss foreign policy and examine, together with guest speakers from the foreign ministry, current international developments and respective foreign policy challenges.

Objective

Students should acquire a sound understanding of Swiss foreign policy and the relevant academic and political debates associated with it.

Content

Nach einer Einführung in die Außenpolitikanalyse behandelt die Lehrveranstaltung zunächst die historischen Grundlagen und die konzeptionelle Entwicklung der schweizerischen Aussenpolitik. Dabei stehen die unterschiedlichen Reaktionen der Schweiz auf die internationalen Neuordnungen nach 1918, 1945 und 1989 und die seitherige Ausgestaltung der Schweizer Außenpolitik im Zentrum.

Auf dieser Basis analysieren wir die derzeitigen weltpolitischen Entwicklungen und deren Bedeutung für die Schweiz. Zu den Themen, die wir diskutieren, gehören die Zeitenwende im Lichte der russischen Aggression gegen die Ukraine, der Nahostkonflikt und weitere Krisen in Europas südlicher Nachbarschaft, die globalen Machtverschiebungen (inkl. Aufstieg Chinas und die Zukunft des Multilateralismus).


Einbezug von Gastreferaten von Mitarbeitenden des Eidgenössischen Departement für auswärtige Angelegenheiten (EDA).

Lecture notes

Students will receive a handout of slides accompanying the lectures.

The course will be supported by an e-learning environment.

Literature

Basic literature is available on Moodle (Advanced Course I). The search for additional literature is a fundamental part of the research process. Students may consult their lecturers if they have any questions.

Competencies

Subject-specific Competencies: Concepts and Theories

Method-specific Competencies: Analytical Competencies

Social Competencies: Leadership and Responsibility

Personal Competencies: Critical Thinking

853-0321-00L Advanced Course II (Seminar)

Abstract

The objective of this two-semester seminar-style course is to write an advanced-level research paper in the field of Strategic Studies. In the second semester, students will write their seminar papers and present them in plenary.

Objective

Students will write their seminar paper based on the research design they developed during Advanced Course I (Seminar). Students should consider the seminar paper as preparation for their BA thesis.

Content

Advanced Course II builds upon Advanced Course I. Within the broader framework of the overall seminar topic (The Strategic Relevance of Surprise, Deception, and Intelligence) and based on the approved research design as developed during Advanced Course I, participants will write their seminar papers in consultation with their lecturers (30 pages max).

Lecture notes

none

Literature

Basic literature is available on Moodle (Advanced Course I). The search for additional literature is a fundamental part of the research process. Students may consult their lecturers if they have any questions.

Prerequisites / notice

Accepted research design (Advanced Course I) is required.

Competencies

Subject-specific Competencies: Concepts and Theories

Method-specific Competencies: Analytical Competencies

Social Competencies: Communication

Personal Competencies: Adaptable and Flexible

853-0061-00L Introduction to Cybersecurity Politics

Abstract

The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures).

Objective

Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and know how technology and politics are interlinked in this area. They understand the security challenges for and the motivations of states to be active in cyberspace offensively and defensively and they are familiar with the consequences for international politics.
We start with an overview of cybersecurity issue from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulatory contexts).

Lecture notes
A script with background information and comments on the literature will be made available at the beginning of the semester.

Literature
Literature for each session will be available on Moodle.

Prerequisites / notice
The lecture is being supported by a website on Moodle.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
</tr>
</tbody>
</table>

Social Psychology of Groups

Abstract
Basic social psychological topics are elaborated, presented, and discussed in the most application-oriented way.

Objective
You are able to recognize and explain various social psychological aspects and factors and to evaluate them in your everyday decisions in terms of planning, content and operations. This means you will be able to assess when various social psychological aspects may play a role in your everyday work. And you are able to assess what this may subsequently mean for your work or leadership processes.

Content

1) Führungpsychologie: Kurzer Einblick in neuere Führungstheorien.
2) Destructive Führung: Was sollten wir nicht machen?
3) Soziale Kognition: Warum und auf Basis welcher wenigen Informationen wir sehr schnell Urteile über Personen treffen.
4) Soziale Wahrnehmung/Attribution: Wie erklären wir uns, dass sich jemand im Alltag in gewisser Art und Weise verhält?
5) Diversity & Frauen & Führung: Woran kann es liegen, dass weibliche Führungskräfte besondere Herausforderungen bei der Ausübung von Führung haben?
6) Sozialer Einfluss: Welche Normen erleben Sie beim Militär? Und wie leiten diese Erwartungen unser Verhalten im Berufsalltag?
7) Gruppenpsychologie: Was heisst "Gruppe"? Wie entwickeln sich (militärische) Gruppen, z.B. in der RS? Welche Prozesse können zwischen Gruppen geschehen?
9) Überzeugungsstrategien
Literature


Plus: Zusatzliteratur

Prerequisites / notice

Lehrangebot im Studiengang Berufsoffizier

Languages

Second Foreign Language

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0402-00L</td>
<td>German, Part II</td>
<td>W</td>
<td>3 credits</td>
<td>4G</td>
<td>S. Schweizer</td>
</tr>
<tr>
<td>Abstract</td>
<td>Based on the knowledge and skills acquired during the first semester, speaking and discussion skills related to military situations are examined and put into practice. Attention is focused on issues such as instruction, qualification and career interviews.</td>
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</tr>
<tr>
<td>Objective</td>
<td>This two-semester German course should enable the French and Italian speaking participants to fulfil their function as professional officers also in the German language.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Content</td>
<td>Read, analyse and write military and civilian documents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Listening comprehension using current radio or TV reports</td>
<td></td>
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<tr>
<td></td>
<td>Practise speaking with group discussions and short presentations</td>
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<tr>
<td></td>
<td>Systematic revision and extension of key grammar points</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Systematic acquisition of general and military vocabulary</td>
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<td></td>
</tr>
</tbody>
</table>

| 853-0404-00L | French, Part II | W    | 3 credits | 4G | S. Schweizer |
| Abstract     | Based on the knowledge and skills acquired during the first semester, speaking and discussion skills related to military situations are examined and put into practice. Attention is focused on issues such as instruction, qualification and career interviews. |
| Objective    | This two-semester French course should enable the German speaking participants to fulfil their function as professional officers also in the French language. |
| Content      | Read, analyse and write military and civilian documents |
|             | Listening comprehension using current radio or TV reports |
|             | Practise speaking with group discussions and short presentations |
|             | Systematic revision and extension of key grammar points |
|             | Systematic acquisition of general and military vocabulary |

Bachelor’s Colloquium and Bachelor’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0315-00L</td>
<td>BA Colloquium</td>
<td>O</td>
<td>2 credits</td>
<td>2K</td>
<td>F. Schimmelfennig</td>
</tr>
<tr>
<td>Abstract</td>
<td>The BA Colloquium prepares students for their BA thesis with regard to content, administration, and methodology. During the colloquium, students choose a topic and a supervisor for their thesis. The skills students have acquired during the course of their studies are also enhanced and optimized.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The students are being prepared administratively and methodologically to write their BA-thesis after completing the course.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>The BA Colloquium prepares students for their BA thesis with regard to content, administration, and methodology. During the colloquium, each student has to choose a topic for his/her BA-thesis. The students also choose their supervisors, whereas the goal is an even distribution of the supervisors. Finally, the methodological competences which were acquired during the first four semesters will be complemented.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Literaturangaben für eine Vertiefung der Inhalte werden im Skript gemacht. Die Anschaffung von Spezialliteratur ist allerdings nicht 

C. Herrmann
Subject-specific Competencies

Lecturers

8D
Creative Thinking

fostered

Techniques and Technologies

fostered

Analytical Competencies

fostered

Project Management

fostered

Personal Competencies

Creative Thinking

fostered

Integrity and Work Ethics

fostered

Self-direction and Self-management

fostered

853-0654-00L Bachelor's Thesis

0
10 credits
8D
Lecturers

Abstract
The Bachelor Thesis completes the Bachelor program and consists of a scientific project carried out independently under the tutelage of an ETH or MILAK lecturer in Public Policy.

Objective
The elaboration of the Bachelor Thesis should further students’ capacities to work independently, structured and scientifically.

► Electives

Recommended Elective Courses

Number Title Type ECTS Hours Lecturers

853-8002-00L The Role of Technology in National and International Security Policy W+ 3 credits 2G M. Leese, A. Dossi

Abstract
The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

Objective
Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

Content

Literature
Literatur für die einzelnen Sitzungen wird auf Moodle bereitgestellt.

Prerequisites / notice
The lecture is being supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@ispo.gess.ethz.ch)

Competencies
Subject-specific Competencies

Concepts and Theories

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

assessed

Problem-solving

assessed

Social Competencies

Communication

fostered

Leadership and Responsibility

fostered

Sensitivity to Diversity

fostered

Personal Competencies

Creative Thinking

assessed

Critical Thinking

assessed

► Additional Elective Courses

These Electives may be chosen from the start of the Bachelor Study Programme.

Number Title Type ECTS Hours Lecturers

376-1033-00L History of Sports W 2 credits 2V M. Gisler

Abstract
Comprehension for development and changes of sports from the ancient world to the presence. Description of sports in services of national idea, from education and health promotion from the middle of the 18th century till this day.

Objective

Literature

376-1107-00L Sport Pedagogy W 2 credits 2V C. Herrmann

Abstract
The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the classical social science / sports pedagogical perspective. Therefore, this lecture will be focused on "pedagogical-psychological aspects of competence development in the context of a multi-perspective physical education".

Objective
Development of pedagogical-psychological competences for the optimisation of future teaching activities. 

- Subject area of educational psychology
- Motivating students in physical education
- Building self-efficacy and strengthen the self-concept
- Promoting positive emotions and a positive attitude to anxiety
- Encouraging self-directed learning
- Leading classes and promoting cooperation
- Communicating with students efficiently
- Reflecting your own expectations critically
- Handling gender issues sensitively
- Promoting inclusion / Strengthening social and moral development
- Dealing with difficult students
- Evaluating achievements of students

Literature
Teaching materials for the individual lectures are provided to the students via moodle.

Primärliteratur
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.

Content
Main Topics
- Introduction to sport psychology
- Cognitions in sports: mental rehearsal and mental training
- Emotions and stress
- Motivation: goal-setting in sports
- Career and career transition in elite sport
- Coach-Athlete-Interaction
- Psychological aspects of sport-injury rehabilitation
- Group dynamics in sport

Lecture notes
Instructional materials for each course will be made available to students. All lecture materials will be available to students on Moodle.

Selected materials for the lecture are available on the Moodle platform.

Literature


860-0023-00L
International Environmental Politics

Objective
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined.

Content
The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
Reading materials and slides will be available via Moodle.

Prerequisites / notice
The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

Credits and Exam
After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.
Competencies  


Personal Competencies: Creative Thinking, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management, Decision-making.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>W</th>
<th>2 credits</th>
<th>2V</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0735-10L</td>
<td>Startups and Law</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>P. Peyrot</td>
</tr>
<tr>
<td>101-0515-00L</td>
<td>Project Management</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>C. G. C. Marxt</td>
</tr>
<tr>
<td>701-0703-00L</td>
<td>Environmental Ethics (University of Zurich)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Abstract:
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective:
The students shall obtain the following competence:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes:
A comprehensive script will be made available online on the moodle platform.

Competencies:

- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Problem-solving
  - Critical Thinking

- Method-specific Competencies
  - Decision-making
  - Problem-solving

- Social Competencies
  - Communication
  - Negotiation

- Personal Competencies
  - Adaptable and Flexible
  - Creative Thinking
  - Critical Thinking

- Media and Digital Technologies
  - Fostered

- Project Management
  - Assessed

- Self-presentation and Social Influence
  - Assessed

- Leadership and Responsibility
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Negotiation
  - Assessed

- Self-awareness and Self-reflection
  - Fostered

- Self-direction and Self-management
  - Assessed

- Decision-making
  - Assessed

- Media and Communication
  - Assessed

- Self-presentation
  - Assessed

- Negotiation
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Self-presentation and Social Influence
  - Assessed

- Leadership and Responsibility
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Negotiation
  - Assessed

- Self-awareness and Self-reflection
  - Fostered

- Self-direction and Self-management
  - Assessed

- Decision-making
  - Assessed

- Media and Communication
  - Assessed

- Self-presentation
  - Assessed

- Negotiation
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Self-presentation and Social Influence
  - Assessed

- Leadership and Responsibility
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Negotiation
  - Assessed

- Self-awareness and Self-reflection
  - Fostered

- Self-direction and Self-management
  - Assessed

- Decision-making
  - Assessed

- Media and Communication
  - Assessed

- Self-presentation
  - Assessed

- Negotiation
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Self-presentation and Social Influence
  - Assessed

- Leadership and Responsibility
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Negotiation
  - Assessed

- Self-awareness and Self-reflection
  - Fostered

- Self-direction and Self-management
  - Assessed

- Decision-making
  - Assessed

- Media and Communication
  - Assessed

- Self-presentation
  - Assessed

- Negotiation
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Self-presentation and Social Influence
  - Assessed

- Leadership and Responsibility
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Negotiation
  - Assessed

- Self-awareness and Self-reflection
  - Fostered

- Self-direction and Self-management
  - Assessed

- Decision-making
  - Assessed

- Media and Communication
  - Assessed

- Self-presentation
  - Assessed

- Negotiation
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Self-presentation and Social Influence
  - Assessed

- Leadership and Responsibility
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Negotiation
  - Assessed

- Self-awareness and Self-reflection
  - Fostered

- Self-direction and Self-management
  - Assessed

- Decision-making
  - Assessed

- Media and Communication
  - Assessed

- Self-presentation
  - Assessed

- Negotiation
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Self-presentation and Social Influence
  - Assessed

- Leadership and Responsibility
  - Assessed

- Sensitivity to Diversity
  - Assessed

- Negotiation
  - Assessed

- Self-awareness and Self-reflection
  - Fostered

- Self-direction and Self-management
  - Assessed
Objective

On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

851-0861-01L Arabic I A1.1

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract

Arabic I leads to A1.1 level on the Common European Framework of Reference for Languages. Arabic I is the first part (A1.1 level) of a four-semester Arabic course. The goal of the course is for participants to acquire basic language skills in speaking, listening comprehension, and the reading and writing of Arabic script.

Objective

Participants are able to use the Arabic language adequately in selected areas. The focus is on speaking; reading and listening comprehension at A1.1 level on the Common European Framework of Reference for Languages; learning Arabic script; and the development of cultural competence. The following content areas are embedded in various communicative tasks: Greeting each other, introducing yourself and speaking about yourself (personal and professional identity, place of residence), making simple phone calls, requesting information, and making appointments.

851-0541-00L Truth and Historical Injustice: The Production of Knowledge about Past Mass Atrocities

Abstract

The course deals with the scientific production of knowledge about past mass atrocities. It looks at the interplay of different disciplines, methods and technological means that have been involved in this production over time. Further, it poses the question of what truth can mean in this context.

Objective

The students a) know the main features of the discussion about the truth in the reconstruction of past events; b) have an understanding of the interplay, but also the coexistence of different scientific methods and technological means in the multidisciplinary production of knowledge about past mass crimes; c) have knowledge of important processes of dealing with past mass crimes from the second half of the 20th century onwards.

Content

When discussing the truthfulness of the academic study of the past, politically and ideologically motivated mass crimes are often cited as historical events in order to substantiate the necessity of a claim to truth. In doing so, moral arguments can be made or historical truth can be asserted as a basic prerequisite for living together in a democratic society under constitutional conditions. The production of knowledge about past atrocities has always been an endeavour in which various scientific disciplines have been involved. The multidisciplinary character of the production of knowledge about mass crimes has become even more accentuated since the second half of the 20th century, not least due to the emergence of new technological possibilities. The course offers a brief introduction to the discussion about the meaning of truth about past events. It looks at how different scientific approaches - from the humanities to the natural sciences - have been involved in coming to terms with mass crimes and how they have been related to each other. It deals with the question of what role certain techniques and technologies have played in the production of knowledge about past atrocities and how this has changed over time. These techniques and technologies range from the evaluation of documents and the taking of testimonies to specialised database programs, genetic analysis or imaging techniques, to digital technologies for the procurement of information on social media and the internet or for the modelling of past events.

In addressing these questions, the course looks at processes of dealing with the past from the middle of the 20th century to the 21st century in Europe, Latin America and Africa.

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Personnel Competencies

Critical Thinking

Public Policy Bachelor - Key for Type

O Compulsory

W+ Eligible for credits and recommended

W Eligible for credits

E- Recommended, not eligible for credits

Z Courses outside the curriculum

Dr Suitable for doctorate

Key for Hours

V lecture

G lecture with exercise

U exercise

S seminar

K colloquium

P practical/laboratory course

A independent project

D diploma thesis

R revision course / private study

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Statistics Master

The following courses belong to the curriculum of the Master's Programme in Statistics. The corresponding credits do not count as external credits even for course units where an enrolment at ETH Zurich is not possible.

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3622-00L</td>
<td>Statistical Modelling</td>
<td>W</td>
<td>7</td>
<td>4G</td>
<td>M. Kalisch</td>
</tr>
<tr>
<td>Abstract</td>
<td>In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.</td>
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<tr>
<td>Objective</td>
<td>Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This is the course unit with former course title &quot;Regression&quot;.</td>
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<tr>
<td>Literature</td>
<td>The main reference for this course is the book &quot;Introduction to Time Series and Forecasting&quot;, by P. J. Brockwell and R. A. Davis</td>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-4623-00L</td>
<td>Time Series Analysis</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>F. Balabdaoui</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.</td>
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<tr>
<td>Objective</td>
<td>The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.</td>
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<tr>
<td>Content</td>
<td>This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.</td>
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<tr>
<td>Literature</td>
<td>The main reference for this course is the book &quot;Introduction to Time Series and Forecasting&quot;, by P. J. Brockwell and R. A. Davis</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Basic knowledge in probability and statistics</td>
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Applied Statistics

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
<tr>
<td>Abstract</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<tr>
<td>Content</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.</td>
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<tr>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
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<td></td>
<td>Concepts and Theories</td>
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<td>assessed</td>
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<td></td>
<td>Techniques and Technologies</td>
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<td>assessed</td>
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<tr>
<td></td>
<td>Method-specific Competencies</td>
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<tr>
<td></td>
<td>Analytical Competencies</td>
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<td>assessed</td>
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<td></td>
<td>Decision-making</td>
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<td>assessed</td>
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<td></td>
<td>Personal Competencies</td>
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<td></td>
<td>Critical Thinking</td>
<td></td>
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<td>assessed</td>
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Mathematical Statistics

The two core courses Fundamentals of Mathematical Statistics (401-3621-00L) and Likelihood Inference (401-8623-00L) are similar in content. Therefore only one of them can be recognised towards the Master's degree in the core course area «Mathematical Statistics».

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3621-00L</td>
<td>Fundamentals of Mathematical Statistics</td>
<td>W</td>
<td>9</td>
<td>4V+1U</td>
<td>J. Ziegel</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this course we study the basics of theoretical statistics. The course includes methods for designing estimators, confidence intervals and tests, and various ways to evaluate the accuracy of estimators, confidence intervals and tests. We consider optimality criteria such as admissibility and minimaxity, as well as Bayesian criteria. We will also present the asymptotic point of view.</td>
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<tr>
<td>Objective</td>
<td>The aim of this course is to gain insight into the main statistical ideas and concepts. The course considers classical low-dimensional models, with pointers towards today's highly complex models.</td>
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### Subject Specific Electives

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
<th>View</th>
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</thead>
<tbody>
<tr>
<td>401-3601-00L</td>
<td>Probability Theory</td>
<td>W</td>
<td>9</td>
<td>4V+1U</td>
<td>V. Tassion</td>
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<td></td>
<td>At most one of the three course units (Bachelor Core Courses)</td>
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<td></td>
<td>401-3461-00L Functional Analysis I</td>
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<td></td>
<td>401-3531-00L Differential Geometry I</td>
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<tr>
<td></td>
<td>401-3601-00L Probability Theory</td>
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<td>can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (<a href="http://www.math.ethz.ch/studiensekretariat">www.math.ethz.ch/studiensekretariat</a>) after having received the credits. Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>Basics of probability theory and the theory of stochastic processes in discrete time</td>
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<tr>
<td></td>
<td>Objective</td>
<td>This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned: measure theory, formalism and probability theory, Dynkin’s lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.</td>
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<td></td>
<td>Content</td>
<td>This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned: measure theory, formalism and probability theory, Dynkin’s lemma and independence, convergence of series of independent random variables, law of large numbers, conditional expectation, martingale convergence theorems, uniform integrability, optional stopping theorem for martingales, the Bienaymé-Galton-Watson process and its R-number, convergence in distribution and the central limit theorem.</td>
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<td></td>
<td>Lecture notes</td>
<td>will be available in electronic form.</td>
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<td></td>
<td></td>
<td>H. Bauer, Probability Theory, de Gruyter 1996</td>
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<td></td>
<td></td>
<td>J. Jacod and P. Protter, Probability essentials, Springer 2004</td>
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<td>A. Klenke, Wahrscheinlichkeitsstheorie, Springer 2006</td>
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<td>D. Williams, Probability with martingales, Cambridge University Press 1991</td>
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<td></td>
<td>Prerequisites / notice</td>
<td>- Measure Theory</td>
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<td></td>
<td></td>
<td>- Basic notions in probability theory (probability space, conditional probability, Borel Cantelli, Dynkin Lemma, random variables, expectation, variance, law of large numbers).</td>
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<td></td>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td>401-3627-00L</td>
<td>High-Dimensional Statistics</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>not available</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>“High-Dimensional Statistics” deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.</td>
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<td></td>
<td>Objective</td>
<td>Knowledge of methods and basic theory for high-dimensional statistical inference</td>
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<td></td>
<td>Content</td>
<td>Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and 1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling</td>
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<td></td>
<td>Prerequisites / notice</td>
<td>Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).</td>
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<tr>
<td>401-4632-15L</td>
<td>Causality</td>
<td>W</td>
<td>5</td>
<td>3G</td>
<td>J. Peters</td>
<td></td>
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<tr>
<td></td>
<td>Abstract</td>
<td>In statistics, we are used to search for the best predictors of some random variable. In many situations, however, we are interested in predicting a system's behavior under manipulations. For such an analysis, we require knowledge about the underlying causal structure of the system. In this course, we study concepts and theory behind causal inference.</td>
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<td></td>
<td>Objective</td>
<td>After this course, you should be able to</td>
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<tr>
<td></td>
<td></td>
<td>- understand the language and concepts of causal inference</td>
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<td>- know the assumptions under which one can infer causal relations from observational and/or interventional data</td>
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<td></td>
<td></td>
<td>- describe and apply different methods for causal structure learning</td>
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<td>- given data and a causal structure, derive causal effects and predictions of interventional experiments</td>
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<tr>
<td></td>
<td>Content</td>
<td>The material covered in this course has a significant overlap with the material that has been covered in 401-3620-22L Student Seminar in Statistics: Causality FS2023.</td>
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<tr>
<td></td>
<td>Literature</td>
<td>Parts of this course will be based on the book “Elements of Causal Inference” (MIT Press, open access). More details will follow.</td>
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<td>Prerequisites / notice</td>
<td>Prerequisites: basic knowledge of probability theory and regression</td>
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<td></td>
<td>Competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td>401-3612-00L</td>
<td>Stochastic Simulation</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>F. Sigrist</td>
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</tbody>
</table>
This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.


A script will be available in English.


Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

The students will be able to use the software R efficiently for data analysis, graphics and simple programming.

This course aims to give the students an understanding of the whole data analytics life cycle in the business world. It shows the expectations of companies and how it is measured. It enables the student to manage successfully all the non-methodological aspects of a data analytics project which are the primary source of failure in end-to-end executions. The student will become familiar with the "business language, and cultural aspects of organizations. It also gives an overview of the data analytics tool, platform, and methods ecosystem for successfully technical data analyses.

The students will be able to use the software R efficiently for data analysis, graphics and simple programming.

Note: This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

Prerequisites: Basic statistics and probability theory and regression

The lecture's presentation slides will be provided.

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Basic knowledge of R equivalent to "Using R .. (part 1)" (= 401-6215-00L) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=20848
Bayesian Statistics

Rough Outline:

Analytical Competencies
Adaptability and Flexibility

Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayesian tests and model selection, empirical Bayes, Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods.

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Analytical Competencies
Decision-making

Media and Digital Technologies
Problem-solving

Communication
Cooperation and Teamwork

Adaptability and Flexibility
Creative Thinking

Critical Thinking
Self-direction and Self-management

Social Competencies

Personal Competencies

Method-specific Competencies

Abstract

The students will learn about methods of kernel smoothing and application of concepts to data. The aim will be to build sufficient interest in the topic and intuition as well as the ability to implement the methods to various different datasets.

Examples

- Parametric estimation methods: selection of important results
  - Method of Least squares: regression & diagnostics
  - Nonparametric curve estimation
    - Density estimation, Kernel regression, Local polynomials, Bandwidth selection, various theoretical results related to consistency
    - Selection of special topics (as time permits, we will discuss some of the following): rapid change points, mode estimation, partial linear models, probability and quantile curve estimation, etc.
  - Applications: potential areas of applications will be discussed such as, change assessment, trend and surface estimation and others.

S. Beran-Ghosh

401-0627-00L

Smoothing and Nonparametric Regression

Objective

The students will learn about methods of kernel smoothing and application of concepts to data. The aim will be to build sufficient interest in the topic and intuition as well as the ability to implement the methods to various different datasets.

Content

- Parametric estimation methods: selection of important results
  - Method of Least squares: regression & diagnostics
  - Nonparametric curve estimation
    - Density estimation, Kernel regression, Local polynomials, Bandwidth selection, various theoretical results related to consistency
    - Selection of special topics (as time permits, we will discuss some of the following): rapid change points, mode estimation, partial linear models, probability and quantile curve estimation, etc.
  - Applications: potential areas of applications will be discussed such as, change assessment, trend and surface estimation and others.

Lecture notes

Summaries or outlines of some of the lecture material may be communicated to registered students by Email at irregular intervals.

References:

- Statistical Inference, by S.D. Silvey, Chapman & Hall.
- Density Estimation, by B.W. Silverman, Chapman and Hall.
- Nonparametric Simple Regression, by J. Fox, Sage Publications.

Additional references will be given out in the lectures.

Prerequisites / notice

Prerequisites: A background in Linear Algebra, Calculus, Probability & Statistical Inference including Estimation and Testing.

447-6289-00L

Sampling Surveys

Objective

Knowledge of the Elements and the process of a sample survey. Understanding of the paradigm of random samples. Knowledge of simple random sampling and stratified random sampling and capability to apply the corresponding methods. Knowledge of further methods of sampling and estimation as well as data preparation and analysis.

Lecture notes

Introduction to the statistical methods of survey research

T. Schoch

401-3628-14L

Bayesian Statistics

Abstract

Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayesian tests and model selection, empirical Bayes, Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods.

S. Beran-Ghosh

Autumn Semester 2024

Page 2358 of 2667
Objective
Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.

Content
Topics that we will discuss are:

- Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)

Lecture notes
A script will be available in English.

Literature


Additional references will be given in the course.

Prerequisites / notice
Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Social Competencies
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Critical Thinking

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Social Competencies
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Critical Thinking

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Objective
I. Discrete-time Markov processes, i.e. Markov chains, e.g. the random walk on the integers
II. Transition probabilities and Doeblin's theorem
III. Stationary probabilities and ergodic properties
IV. Continuous-time Markov processes, e.g. the Poisson process
V. Reversibility

Literature
An Introduction to Markov Processes: Daniel W. Stroock

Prerequisites / notice
Recommended: Analysis III (measure theory)

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Social Competencies
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Critical Thinking

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Objective
Introduction to various mathematical aspects of Data Science.

Abstract
Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

Objective
Introduction to various mathematical aspects of Data Science.

Abstract
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.
AI is having a profound impact on science by accelerating discoveries across physics, chemistry, biology, and engineering. This course aims to present a highly topical selection of AI applications across these fields. Emphasis will be placed on using AI, particularly deep learning, to understand systems modelled by PDEs, and key scientific machine learning concepts and themes will be discussed.

Learning objectives:
- Awareness of advanced applications of AI in the sciences and engineering
- Familiar with the design, implementation, and theory of these algorithms
- Understanding the pros/cons of using AI and deep learning for science
- Understanding key scientific machine learning concepts and themes

A selection of the following topics will be presented in the lectures:

1. Key scientific tasks common to many scientific domains, such as simulation, inverse problems, equation discovery, design, and control problems, and issues with traditional methods for solving them
2. Physics-informed neural networks for solving forward, inverse and equation discovery problems related to PDEs
3. Neural operators, including Fourier neural operators and DeepONets, for learning efficient surrogate models, and their theoretical foundations
4. Differentiable scientific algorithms, neural differential equations, and the benefits of hybrid workflows
5. AI for symbolic regression and equation discovery
6. Applications of graph neural networks in science
7. Guest lecturers on AI for chemistry and biology
8. Large language models and other Foundation models for scientific discovery

Applications using these techniques will be illustrated across fluid dynamics, wave physics, medical physics, molecular design, and computational biology. Several examples where AI algorithms outperform traditional scientific workflows will be shown.

Lecture notes
Lecture slides, recordings, and tutorials will be available on Moodle.

Prerequisites / notice
- An understanding of basic ML concepts including supervised learning, overfitting/underfitting, optimisation, and neural networks is required; you should understand the main concepts in the ETH 252-0220-00L Introduction to Machine Learning course (but note, completing this course is not a formal requirement)
- Familiar with PDEs and numerical methods for solving them
- Familiar with Python and some practical familiarity with deep learning frameworks (e.g. PyTorch, TensorFlow, or Keras)

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity
Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

401-3931-00L Responsible Machine Learning with Insurance Applications

W 4 credits 2G M. Mayer, C. Lorentzen-Geiser
This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

This lecture will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Prerequisites: Good knowledge in statistics/probability theory, statistical modelling and Python (or R) programming are assumed.

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies

Method-specific Competencies

- fostered

252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A C. Cottrini Jimenez

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

- The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-3005-00L Natural Language Processing W 7 credits 3V+3U+1A R. Cotterell

Abstract

This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective

The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content

This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature

Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

227-0423-00L Neural Network Theory W 4 credits 2V+1U H. Bölcskei

Abstract

Does not take place this semester.

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.
Content

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

Lecture notes

Detailed lecture notes are available on the course webpage
https://www.mins.ee.ethz.ch/teaching/intnt/

Prerequisites / notice

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann

Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice

This course is aimed at students with a strong mathematical background in linear algebra, analysis, and probability theory in particular.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://mi2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://mi2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

263-5210-00L Probabilistic Artificial Intelligence W 8 credits 3V+2U+2A A. Krause

Abstract

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics. The course is designed for graduate students.

Objective

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- Technology Competencies
  - Communication
  - Cooperation and Teamwork

- Personal Competencies
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics

263-5300-00L Guarantees for Machine Learning W 7 credits 3V+1U+2A F. Yang
**Abstract**

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

**Content**

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

**Prerequisites / notice**

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression” / “Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

**Competencies**

- Subject-specific Competencies: Concepts and Theories
  - Analytical Competencies: assessed
  - Problem-solving: assessed
- Social Competencies: Communication
  - Cooperation and Teamwork: assessed
- Personal Competencies: Creative Thinking
  - Critical Thinking: assessed

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<table>
<thead>
<tr>
<th>263-2400-00L</th>
<th>Reliable and Trustworthy Artificial Intelligence</th>
<th>W 6 credits</th>
<th>2V+2U+1A</th>
<th>M. Vechev</th>
</tr>
</thead>
</table>

**Abstract**

Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

**Objective**

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

**Content**

The course is split into 4 parts:

- **Robustness of Machine Learning**
  - Adversarial attacks and defenses on deep learning models.
  - Certified training of deep neural networks (combining symbolic and continuous methods).
- **Privacy of Machine Learning**
  - Threat models (e.g., stealing data, poisoning, membership inference, etc.).
  - Attacking federated machine learning (across vision, natural language and tabular data).
  - Differential privacy for defending machine learning.
  - AI Regulations and checking model compliance.
- **Fairness of Machine Learning**
  - Introduction to fairness (motivation, definitions).
  - Enforcing individual fairness (for both vision and tabular data).
  - Enforcing group fairness (e.g., demographic parity, equalized odds).
  - We discuss all previous topics, as well as programmability, in the context of latest foundation models (e.g., LLMs).

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

The coding project will utilize Python and PyTorch. Thus some programming experience in Python is expected. Students without prior knowledge of PyTorch are expected to acquire it early in the course by solving exercise sheets.

### Competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Problem-solving: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed

### Prerequisites / notice

263-5056-00L  
**Applications of Deep Learning on Graphs**  
W 4 credits  
2G+1A  
G. Rättsch

**Abstract**

Graphs are an incredibly versatile abstraction to represent arbitrary structures such as molecules, relational knowledge or social and traffic networks. This course provides a practical overview of deep (representation) learning on graphs and their applications.

**Objective**

Many established deep learning methods require dense input data with a well-defined structure (e.g. an image, a sequence of word embeddings). However, many practical applications deal with sparsely connected and complex data structures, such as molecules, knowledge graphs or social networks. Graph Neural Networks (GNNs) and general representation learning on graphs have recently experienced a surge in popularity because it addresses the challenge to effectively learn representations over said structures. In this course, we aim to understand the fundamental principles of deep (representation) learning on graphs, the similarities and differences to other concepts in deep learning, as well as the unique challenges from a practical point of view. Finally, we provide an overview of recent applications of graph neural networks.

**Content**

Introduction to GNN concepts: 1) problem-solving on graphs (node-, edge-, graph-level objectives), structural priors (inductive biases) of graph data, applications for graph learning, 2) Graph Neural Networks: convolutional, attentional, message passing; overview on the zoo of published operators. Relations to Transformers and DeepSets. 3) Expressivity of GNNs. 4) Scalability of Graph Neural Networks: Subsampling, Clustering (Pooling). 5) Augmentations and self-supervised learning on Graphs Application: Drug Discovery, Knowledge graphs. Temporal GNNs, Geometric GNNs, Deep Generative Models for Graphs.

263-3210-00  
Dep Deep learning or 263-0008-00  
Computational Intelligence Lab;  
252-0220-00 Introduction to Machine Learning;  
Statistics/Probability;  
Programming in Python;  
Unix Command Line.

### Prerequisites / notice

263-5351-00L  
**Machine Learning for Genomics**  
W 6 credits  
2G+2U+1A  
V. Boeva

**Abstract**

The course reviews solutions provided by machine learning to the most challenging questions in human genomics.

**Objective**

Over the last few years, the parallel development of machine learning methods and molecular profiling technologies for human cells, such as sequencing, created an extremely powerful tool to get insights into the cellular mechanisms in healthy and diseased contexts. In this course, we will discuss the state-of-the-art machine learning solving the aforementioned problem of human genomics. At the end of the course, you will be familiar with (1) classical and advanced machine learning architectures used in genomics, (2) bioinformatics analysis of human genomic and transcriptomic data, and (3) data types used in this field.

**Content**

- Short introduction to major concepts of molecular biology: DNA, genes, genome, central dogma, transcription factors, epigenetic code, DNA methylation, signaling pathways
- Prediction of transcription factor binding sites, open chromatin, histone marks, promoters, nucleosome positioning (convolutional neural networks, position weight matrices)
- Prediction of variant effects and gene expression (hidden Markov models, topic models)
- Deconvolution of mixed signal (NMF, ICA)
- DNA, RNA and protein folding (RNN, LSTM, transformers)
- Data imputation for single-cell RNA-seq data, clustering and annotation (diffusion and methods on graphs)
- Batch correction (autoencoders, optimal transport)
- Survival analysis (Cox proportional hazard model, regularization penalties, multi-omics, multi-tasking)

### Prerequisites / notice

Introduction to Machine Learning, Statistics/Probability, Programming in Python, Unix Command Line

### Competencies

**Subject-specific Competencies**
- Concepts and Theories: fostered
- Techniques and Technologies: fostered

**Social Competencies**
- Communication: assessed

### Prerequisites / notice

401-6282-00L  
**Statistical Analysis of High-Throughput Genomic and Transcriptomic Data (University of Zurich)**  
W 5 credits  
3G  
H. Rehrauer

**Abstract**

A range of topics will be covered, including basic molecular biology, genomics technologies and in particular, a wide range of statistical and computational methods that have been used in the analysis of DNA microarray and high throughput sequencing experiments.

**Objective**

- Understand the fundamental “scientific process” in the field of Statistical Bioinformatics
- Be equipped with the skills/tools to preprocess genomic data (Unix, Bioconductor, mapping, etc.) and ensure reproducible research (Sweave)
- Have a general knowledge of the types of data and biological applications encountered with microarray and sequencing data
- Have the general knowledge of the range of statistical methods that get used with microarray and sequencing data
- Gain the ability to apply statistical methods/knowledge/software to a collaborative biological project
- Gain the ability to critically assess the statistical bioinformatics literature
- Write a coherent summary of a bioinformatics problem and its solution in statistical terms

**Content**

Lectures will include: microarray preprocessing; normalization; exploratory data analysis techniques such as clustering, PCA and multidimensional scaling; controlling error rates of statistical tests (FPR versus FDR versus FWER); Limma (linear models for microarray analysis); mapping algorithms (for RNA/ChIP-seq); RNA-seq quantification; statistical analyses for differential count data; isoform switching; epigenomics data including DNA methylation; gene set analyses; classification

**Lecture notes**

Lecture notes, published manuscripts

**Prerequisites / notice**

Prerequisites: Basic knowledge of the programming language R, sufficient knowledge in statistics

Former course title: Statistical Methods for the Analysis of Microarray and Short-Read Sequencing Data
Discussion of the different statistical methods that are used in clinical research.

Abstract

Discussion of the different statistical methods that are used in clinical research. Among other subjects the following will be introduced: sample size calculation, randomization and blinding, analysis of clinical trials (parallel groups design, analysis of covariance, crossover design, equivalence studies), intention-to-treat analysis, multiple testing, group sequential methods, adaptive designs, diagnostic studies, and agreement studies.

Content


Prerequisites / notice

Basic knowledge of the programming language R, sufficient knowledge in calculus, linear algebra, probability, statistics

Seminar or Semester Paper

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3620-74L</td>
<td>Student Seminar in Statistics: ...</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>Y. Chen</td>
</tr>
<tr>
<td>401-3630-04L</td>
<td>Semester Paper</td>
<td>W</td>
<td>4 credits</td>
<td>6A</td>
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<td>401-3630-06L</td>
<td>Semester Paper</td>
<td>W</td>
<td>6 credits</td>
<td>9A</td>
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<tr>
<td>252-5051-00L</td>
<td>Advanced Topics in Machine Learning</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Cotterell, M. El-Assady, N. He, F. Yang</td>
</tr>
</tbody>
</table>

Free Electives

Several further courses offered at the University of Zurich belong to the curriculum of the Master's Programme in Statistics. With the consent by the Advisor (http://stat.ethz.ch/~kalisch/) such a course is eligible as a free elective.

Science in Perspective

Two credits are needed from the "Science in Perspective" programme with language courses excluded if three credits from language courses have already been recognised for the Bachelor's degree. 

Course Catalogue

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2365 of 2667
courses (level B2 upwards) in the European languages English, French, Italian and Spanish are recognised. German language courses are recognised from level C2 upwards.)

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MATH

**Master’s Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-2000-00L</td>
<td>Scientific Works in Mathematics</td>
<td>O</td>
<td>0</td>
<td></td>
<td>D. Possamaï</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)

**Objective**

Learn the basic standards of scientific works in mathematics.

- Types of mathematical works
- Publication standards in pure and applied mathematics
- Data handling
- Ethical issues
- Citation guidelines

**Prerequisites / notice**


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-2000-01L</td>
<td>Lunch Sessions – Thesis Basics for Mathematics Students</td>
<td>Z</td>
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<td>Speakers</td>
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</table>

**Abstract**

Optional MathBib training course

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>401-4990-02L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30</td>
<td>57D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

The master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

**Objective**

Thesis work should prove the students’ ability to independent, structured and scientific working.

**Content**

Five-month project to solve a research question. The content can be more theoretical (e.g. proving a new result) or applied (developing new methods or making a very sophisticated application and adapting existing methods).

**Prerequisites / notice**

Supervisors are chosen on a first-come-first-served basis. Collaborations with industry are possible.

**Course Units for Additional Admission Requirements**

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>406-0173-AAL</td>
<td>Linear Algebra I and II</td>
<td>E-</td>
<td>6</td>
<td>13R</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

**Abstract**

Linear algebra is an indispensable tool of engineering mathematics. The course is an introduction to basic methods and fundamental concepts of linear algebra and its applications to engineering sciences.

**Objective**

After completion of this course, students are able to recognize linear structures and to apply adequate tools from linear algebra in order to solve corresponding problems from theory and applications. In addition, students have a basic knowledge of the software package Matlab.

**Content**


Reading:

Gilbert Strang “Introduction to linear algebra”, Wellesley-Cambridge Press: Chapters 1-6, 7.1-7.3, 8.1, 8.2, 8.6


406-0243-AAL
Analysis I and II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers. Mathematical formulation of technical and scientific problems.

Content
Complex numbers.
Calculus for functions of one variable with applications.
Simple Mathematical models in engineering.

Literature
Textbooks in English:

Textbooks in German:
- M. Akveld, R. Sperb: Analysis I, vdf
- M. Akveld, R. Sperb: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

406-0603-AAL
Stochastics (Probability and Statistics)
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed

Personal Competencies
- Self-direction and Self-management: assessed

406-2604-AAL
Probability and Statistics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract
- Probability spaces
- Discrete models, Random walk
- Conditional probabilities, independence
- Continuous models
- Limit theorems
- Methods of moments
- Maximum likelihood estimation
- Hypothesis testing
- Confidence intervals
- Introductory Bayesian statistics
- Linear regression model

Objective
The first part of the course gives an overview of the main concepts needed to understand probability theory (sample spaces, discrete models, random walk, continuous models and limit theorems such as the Laws of Large Numbers and the Central limit theorem). It will be based on the German script "Wahrscheinlichkeitsrechnung und Statistik".

The second part covers some fundamental results of mathematical statistics including estimation methods, hypothesis testing as well as the linear regression model. For this part, we will use the script "Statistics for Mathematics". Both scripts are available at https://www.stat.math.ethz.ch/~fadouab/

Content
Probability:
Chapters 1-5 (Probabilities and events, Discrete and continuous random variables, Generating functions) and Sections 7.1-7.5 (Convergence of random variables) from the book "Probability and Random Processes". Most of this material is also covered in Chap. 1-5 of "Mathematical Statistics and Data Analysis", on a slightly easier level.

Statistics:
Sections 8.1 - 8.5 (Estimation of parameters), 9.1 - 9.4 (Testing Hypotheses), 11.1 - 11.3 (Comparing two samples) from "Mathematical Statistics and Data Analysis".

Lecture notes
(*) Wahrscheinlichkeitsrechnung und Statistik

(*) Statistics for Mathematics

Both scripts can be found at https://www.stat.math.ethz.ch/~fadouab/

Literature
A. Irle, Wahrscheinlichkeitstheorie und Statistik, Teubner (2001)
### First Year Compulsory Courses

#### First Year Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0141-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5 credits</td>
<td>4V+1U</td>
<td>M. Akka Ginosar, R. Prohaska</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Introduction to Linear Algebra</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Basic knowledge of linear algebra as a tool for solving engineering problems. Understanding of abstract mathematical formulation of technical and scientific problems. Together with Analysis we develop the basic mathematical knowledge for an engineer.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>The lecturer will provide course notes.</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>K. Nipp, D. Stoffer, Lineare Algebra, VdF Hochschulverlag ETH</td>
</tr>
<tr>
<td></td>
<td>Competencies</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Subject-specific Competencies</td>
<td></td>
<td></td>
<td></td>
<td>Concepts and Theories assessed</td>
</tr>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td></td>
<td></td>
<td></td>
<td>Analytical Competencies assessed</td>
</tr>
<tr>
<td></td>
<td>Personal Competencies</td>
<td></td>
<td></td>
<td></td>
<td>Critical Thinking fostered</td>
</tr>
<tr>
<td>252-0845-00L</td>
<td>Computer Science I</td>
<td>O</td>
<td>5 credits</td>
<td>2V+2U</td>
<td>M. Lüthi, A. Streich</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The course covers the basic concepts of computer programming.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Basic understanding of programming concepts. Students will be able to write and read simple programs and to modify existing programs. In the course &quot;Computer Science I&quot;, the competency of programming is taught, applied and examined. Furthermore modeling is taught and applied.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>variables, types, control structures, functions, scoping, recursion, object-oriented programming. The programming language is Python.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>The slides and lecture notes will be made available for download on the course website.</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>Learn to Code by Solving Problems A Python Programming Primer Daniel Zingaro</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Python Crash Course</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A Hands-On, Project-Based Introduction to Programming Eric Matthes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Python for Data Analysis Data wrangling with pandas, NumPy &amp; Jupyter, 3rd Edition Wes McKinney</td>
</tr>
<tr>
<td></td>
<td>Competencies</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Subject-specific Competencies</td>
<td></td>
<td></td>
<td></td>
<td>Concepts and Theories assessed</td>
</tr>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td></td>
<td></td>
<td></td>
<td>Analytical Competencies assessed</td>
</tr>
<tr>
<td></td>
<td>Personal Competencies</td>
<td></td>
<td></td>
<td></td>
<td>Critical Thinking fostered</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented. A further aim of the lecture is that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>- Biodiversity: variation, threats and conservation - Influence of environmental factors on organisms; adaptation to environmental conditions - Population dynamics: causes, description, prediction and regulation - Interactions between species (competition, coexistence, predation, parasitism, food webs) - Ecological communities: structure, stability, succession - Ecosystems: compartments, material and energy flows</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>Documents, lecture slides, exercises and relevant literature are available in Moodle. The documents for the next lecture will be available on Friday morning at the latest.</td>
</tr>
</tbody>
</table>
Competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: fostered

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: fostered
- Sensitivity to Diversity: fostered

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

151-0223-10L Engineering Mechanics

Type: O 4 credits 2V+2U+1K  P. Tiso

Abstract

Introduction to engineering mechanics: kinematics, statics and dynamics of rigid bodies and systems of rigid bodies.

Objective

Students can solve problems of elementary engineering mechanics.

Content

- Basic notions: position and velocity of particles, rigid bodies, planar motion, kinematics of rigid body, force, couple, power.
- Statics: static equivalence, force-couple system, center of forces, centroid, principle of virtual power, equilibrium, constraints, statics, friction.
- Dynamics: acceleration, inertial forces, d'Alembert's Principle, Newton's Second Law, principles of linear and angular momentum, equations of planar motion of rigid bodies.

Lecture notes: yes, in German

Literature


First Year Examination Block B

401-0241-00L Analysis I

Type: O 7 credits 4V+2U  M. Akveld, G.-I. Ionita

Abstract

Mathematical tools for the engineer

Objective

Mathematics as a tool to solve engineering problems. Mathematical formulation of technical and scientific problems.

Content

- Complex numbers.
- Calculus for functions of one variable with applications.
- Simple Mathematical models in engineering.

Lecture notes: Wird auf der Vorlesungshomepage zu Verfügung gestellt.

Literature

- Urs Stammbach, "Analysis III" (erhältlich im ETH Store); https://people.math.ethz.ch/~stammb/analysisskript.html

529-2001-02L Chemistry I

Type: O 4 credits 2V+2U  J. Cvengros, J. E. E. Buschmann, P. Funck, R. Verel

Abstract

General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course "Chemistry I", the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

Objective

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content

1. Stoichiometry
   - Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
4. Basics of chemical thermodynamics
   - System and surroundings. Description of state and change of state of chemical systems.
5. First law of thermodynamics
6. Second law of thermodynamics
   - Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. Gibbs energy and chemical potential.
8. Chemical equilibrium
9. Acids and bases
10. Dissolution and precipitation.
    - Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes: Online-Skript mit durchgerechneten Beispielen.
Literature
Weiterführende Literatur:
Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(englisch)

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Additional First Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0004-00L</td>
<td>Introduction into Environmental Engineering</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>P. Molnar, R. Boes, P. Burlando, I. Hajnsek, S. Hellweg, M. Maurer, E. Morgenroth, R. Stocker, J. Wang</td>
</tr>
</tbody>
</table>

Abstract
In this course students are introduced to how environmental problems in the areas of water quantity and quality, waste production and recycling, air pollution control, are formulated and solved with engineering methods. The course makes a connection between the theoretical Bachelor foundation classes and practical topics of environmental engineering in six main thematic areas.

Objective
After completing this course, the student will be able to:
- formulate key global environmental problems
- develop a systems perspective and solutions to the problems (critical thinking)
- identify and solve simple numerical problems in the domain areas
- understand why/how we use data/models in environmental engineering
- develop own interest in the domain areas and see career opportunities

Content
Topics of study:
0. Introduction – description of the Earth System, main stressors, global warming, introduction into the methods and goals of environmental engineering.
1. Water Science & Engineering – definition of the global water cycle and hydrological regimes, surface/subsurface flow equations (advection, diffusion), water resources management, climate change.
4. River and Hydraulic Engineering – utility hydraulic engineering (hydropower production), protective hydraulic engineering (flood protection), waters protection (river restoration, ecological measures at hydropower plants).
5. Air Quality – air quality parameters, main air pollutants, air quality in cities/indoor, emission control, the plume dispersion model.
6. Earth Observation – satellite observation of the Earth System from space, methods, environmental applications (glaciers, forest, land surface change)

Lecture notes
Course will take place in English and German (bilingual). The English textbook by Masters and Ela (see below) will be complemented by instructors materials to the individual thematic topics. Lecture presentations will be the main study material. There is no formal Script.

Literature
  - lecture presentations and selected papers

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving fostered
- Project Management fostered

Social Competencies
- Communication fostered
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered

Personal Competencies
- Creative Thinking fostered
- Critical Thinking fostered
- Self-awareness and Self-reflection fostered

Second and Third Year Compulsory Courses

Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>102-0293-00L</td>
<td>Hydrology</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>P. Burlando</td>
</tr>
</tbody>
</table>
Abstract
The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the rainfall-runoff transformation, thereby including flood analysis.

Objective
Know the main features of engineering hydrology. Apply methods to estimate hydrological variables for dimensioning hydraulic structures and managing water resources.

Content
The hydrological cycle: global water resources, water balance, space and time scales of hydrological processes.

Precipitation: mechanisms of precipitation formation, precipitation measurements, variability of precipitation in space and time, precipitation regimes, point basin precipitation, isohyetal method, Thiessen polygons, storm rainfall, design hyetograph.

Interception: measurement and estimation.

Evaporation and evapotranspiration: processes, measurement and estimation, potential and actual evapotranspiration, energy balance method, empirical methods.

Infiltration: measurement, Horton's equation, empirical and conceptual models, phi-index and percentage method, SCS-CN method.

Surface runoff and subsurface flow: Hortonian and Dunnian surface runoff, streamflow measurement, streamflow regimes, annual hydrograph, flood hydrograph analysis – baseflow separation, flow duration curve.

Basin characteristics: morphology, topographic and phreatic divide, hypsometric curve, slope, drainage density.

Rainfall-runoff models (R-R): rational, linear model of rainfall-runoff transformation, concept of the instantaneous unit hydrograph (IUH), linear reservoir, Nash model.

Flood estimation methods: flood frequency analysis, deterministic methods, probabilistic methods (e.g. statistical regionalisation, indirect R-R methods for flood estimation, rational method).

Erosion and sediment transport: watershed scale erosion, soil erosion by water, estimation of surface erosion, sediment transport.

Snow (and ice) hydrology: snow characteristic variables and measurements, estimation of snowmelt processes by the energy budget equation and conceptual melt models (temperature index method and degree-day method), snowmelt runoff.

Lecture notes
The lecture notes as well as the lecture presentations and handouts may be downloaded from the website of the Chair of Hydrology and Water Resources Management.

Literature

Prerequisites / notice
Knowledge of statistics is a prerequisite. The required theoretical background is covered, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows:

Elementary data processing: hydrological measurements and data, data visualisation (graphical representation and numerical parameters). Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.

101-0203-01L Hydraulics I O 5 credits 3V+1U R. Stocker
Abstract
The course teaches the basics of hydromechanics, relevant for civil and environmental engineers.

Objective
In the course "Hydraulics I", the competency of process understanding is taught, applied and examined. Furthermore system understanding and measurement methods are taught.

Content
Properties of water, hydrostatics, stability of floating bodies, continuity, Euler equation of motion, Navier-Stokes equations, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids vs. real fluids, boundary layer, pipe flow, open channel flow, flow measurements, demonstration experiments in the lecture hall.

Lecture notes
Script and collection of previous problems

Literature
Bołtch, Technische Hydromechanik 1, Verlag Bauwesen, Berlin

102-0635-11L Air Quality Technics O 3 credits 2G J. Wang
Abstract
The lecture provides different strategies and techniques for emission reduction and pollutant removal from exhaust air flows. The fundamental theories, practical designs and application scenarios of each technique are covered. The basic knowledge is deepened by the discussion of specific air pollution problems of today's society.

Objective
The students gain general knowledge of air pollution and study the methods used for air pollution control. The students know the different strategies of air pollution control and are familiar with their scientific fundamentals. The students can evaluate possible control methods and equipment, design control systems and estimate their efficiencies and costs. They are able to incorporate goals concerning air quality into their engineering work.

Content
The reduction of the formation of pollutants is done by modifying the processes (process-integrated measures) and by different engineering operations for the cleaning of waste gas (downstream pollution control). It will be demonstrated, that the variety of these procedures can be traced back to the application of a few basic physical and chemical principles.

Procedures for the removal of particles (inertial separator, filtration, electrostatic precipitators, scrubbers) with their different mechanisms (field forces, impaction and diffusion processes) and the modelling of these mechanisms will be covered.

Procedures for the removal of gaseous pollutants and the description of the driving forces involved, as well as the equilibrium and the kinetics of the relevant processes (absorption, adsorption as well as thermal, catalytic and biological conversions) will be covered.

Discussion of the technical possibilities to solve the actual air pollution problems will be conducted.

Lecture notes
Jing Wang, Air pollution control technics

Literature
List of literature included in script

Prerequisites / notice
College lectures on basic physics, chemistry and mathematics.
### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-4001-00L</td>
<td>Microbiology</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>M. Schuppler, M. La Fortezza, M. Pilhofer, S. Robinson</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Knowing theoretical aspects of geographic information regarding data acquisition, representation, analysis and visualisation. Knowing the fundamentals of geoinformation technologies for the realization, application and operation of geographic information systems in engineering projects.</td>
</tr>
<tr>
<td>402-0023-01L</td>
<td>Physics</td>
<td>O</td>
<td>7</td>
<td>5V+2U</td>
<td>J. Faist</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>This course gives an overview of important concepts in classical dynamics, thermodynamics, electromagnetism, quantum physics, atomic physics, and special relativity. Emphasis is placed on demonstrating key phenomena using experiments, and in developing skills for quantitative problem solving.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The goal of this course is to make students able to explain and apply the basic principles and methodology of physics to problems of interest in modern science and engineering. An important component of this is learning how to solve new, complex problems by breaking them down into parts and applying simplifications. A secondary goal is to provide students an overview of important subjects in both classical and modern physics.</td>
</tr>
<tr>
<td>103-0233-10L</td>
<td>Fundamentals of GIS</td>
<td>O</td>
<td>6</td>
<td>5G</td>
<td>M. Raubal</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Fundamentals of geographic information systems: spatial data modeling; metrics &amp; topology; vector, raster and network data; thematic data; spatial statistics; system architectures, data quality; spatial queries and analysis; geovisualisation; spatial databases, labs with GIS software</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Knowing theoretical aspects of geographic information regarding data acquisition, representation, analysis and visualisation. Knowing the fundamentals of geoinformation technologies for the realization, application and operation of geographic information systems in engineering projects.</td>
</tr>
</tbody>
</table>
The objective of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:

1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

More specifically upon completion of the course, you will have gained insight into:

• how to structure the large amount of information that is often associated with attempting to modify complex systems
• how to set goals and define constraints in the engineering of complex systems
• how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking
• how to assess values of benefits to stakeholders that are not in monetary units
• how to assess whether it is worth obtaining more information in determining optimal solutions in light of the bigger picture
• the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e., ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions in complex systems.
The lectures are structured as follows:

1. Introduction – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms. A high-level overview of the main principles of System Engineering. The expectations of your efforts throughout the semester.
2. Situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
3. Goals and constraints – How to set goals and constraints to identify the best solutions as clearly as possible.
4. Generation of possible solutions – How to generate possible solutions to problems, considering multiple stakeholders.
5. The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, weighting, and expected value.
6. The idea behind the supply and demand curves and revealed preference methods.
7. The concept of equivalence, including the time value of money, interest, life times and terminal values.
8. The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Internal rates of return.
9. How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.
10. Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. Linear programming and the simplex method.
11. How sensitivity analysis is conducted using linear programming.
12. How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.
13. How to set up and solve problems when there are multiple objectives.

The course uses a combination of qualitative and quantitative approaches.

Lecture notes

• The lecture materials consist of a script, the slides, example calculations in Excel, Moodle quizzes, and exercises.
• The lecture materials will be distributed via Moodle before each lecture.

Literature

Appropriate literature in addition to the lecture materials will be handed out when required via Moodle.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

851-0723-10L Environmental Law

Abstract

This class introduces students to the fundamentals of legal systems, focusing on environmental law. It covers the fundamentals of constitutional and administrative law, as opposed to private and criminal law. The class will focus on concepts, terminology and procedures of Swiss environmental law, supplemented through case studies.

Objective

Students learn fundamental structures of the legal system, understand core concepts and selected problems of public law, focusing on Swiss and European environmental law. These insights can be applied in further law courses, in particular in the course "Environmental law: Areas and Case Studies."

Content


Lecture notes

Christoph Jäger/Andreas Bühler, Schweizerisches Umweltrecht, Bern 2016

Literature

Weitere Literaturangaben folgen in der Vorlesung

Laboratory Course in Environmental Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>102-0527-10L</td>
<td>Environmental Laboratory I</td>
<td>O</td>
<td>4</td>
<td>4P</td>
<td>D. Braun, L. Biolley, M. Vogt, L. von Känel</td>
</tr>
</tbody>
</table>

Abstract

A practical introduction to important measurement methods for environmental engineers. Results of the measurements are compared to models and deviations are quantified with statistical methods.

Objective

The laboratory offers students an insight into various experimental methods relevant to environmental engineering. The students deal with problems of measurement technology and measurement uncertainty, learn to characterize systems and to compare and discuss the results of the measurements with simple models. The work is documented with scientific reports or presented in presentations.
Es werden Experimente zu den folgenden Themen durchgeführt:
- Verweilzeit in einer Rührkesselkaskade
- Hydrodynamische Versuche
- Photometrische Bestimmungen von Inhaltsstoffen
- Carbonatgleichgewicht
- Gasgleichgewichte

Die folgenden analytischen Methoden werden dabei eingesetzt:
- UV/VIS-Spektroskopie
- pH
- Druckmessungen

Lecture notes
Wird abgegeben

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
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<td>Method-specific Competencies</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>fostered</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
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<tr>
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<tr>
<td>Personal Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
</tr>
</tbody>
</table>

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Subject-Specific Electives

River and Hydraulic Engineering

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>101-1249-00L</td>
<td>Hydraulics of Engineering Structures</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>I. Albayrak, F. Evers</td>
</tr>
</tbody>
</table>

Abstract
Hydraulic fundamentals are applied to hydraulic structures for wastewater, flood protection and hydropower. Typical case studies from engineering practice are further described.

Objective
Understanding and quantification of fundamental hydraulic processes with particular focus on hydraulic structures for wastewater, flood protection and hydropower.

Content
1. Introduction & Basic equations
2. Losses in flow & Maximum discharge
3. Uniform flow & Critical flow
4. Hydraulic jump & Stilling basin
5. Backwater curves
6. Weirs & End overfall
7. Side weir & Side channel
8. Bottom opening, Venturi & Culverts, Restrictors, Inverted siphons
9. Fall manholes & Vortex drop
10. Supercritical flow & Special manholes
11. Aerated flows & Low level outlets
12. Hydraulics of sediment bypass tunnels
13. Vegetated flows - Introduction & Application
14. Summary

Lecture notes
Text books

Literature

101-0113-10L Theory of Structures (for Environmental Engineering) W 3 credits 2.5G B. Sudret

Abstract
Introduction to structural mechanics, statically determinate beams and frame structures, trusses. Stresses in statically determinate structures.

Objective
- Understanding the response of elastic beam and frame structures
- Ability to correctly apply the equilibrium conditions
- Understanding the basics of continuum mechanics
- Computation of stresses in elastic structures

Content
- Equilibrium, reactions, static determinacy
- Internal forces (normal and shear forces, moments)
- Arches and cables
- Elastic trusses
- Influence lines
- Basics of continuum mechanics
- Stresses in elastic beams

Lecture notes
Bruno Sudret, "Einführung in die Baustatik", 2021
Available on Moodle with exercises.

Literature
B. Sudret, Baustatik - eine Einführung, 2022, Springer Vieweg.

Data: 02.07.2024 12:39   Autumn Semester 2024   Page 2376 of 2667

Vertiefung der Grundlagen für die Dimensionierung anspruchsvoller Bauwerke mithilfe der numerischen Simulation und Darstellung der Ergebnisse für Zielgruppen in der schweizerischen Wasserwirtschaft.

**Abstract**

**Objective**

**Content**

**Lecture notes**

**Prerequisites / notice**

**Competencies**

**Method-specific Competencies**

**Social Competencies**

**Personnel Competencies**

**Literature**

102-0215-00L Urban Water Management II

<table>
<thead>
<tr>
<th>Number</th>
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<td>102-0215-00L</td>
<td>Urban Water Management II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>P. Stauf</td>
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</table>


Skript und einzelne Dokumente werden ausgegeben. Unterlagen zur Vorlesung werden auf der SPUR-Kursseite und/oder auf Moodle direkt zur Verfügung gestellt.

- Durchführung von Exkursionen und Besichtigungen.
- Präsentation von aktueller Raumplanungspolitik und Fallbeispielen aus der Schweiz und anderen Ländern.

**Literature**

103-0313-00L Spatial Planning and Landscape Development

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
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<td>103-0313-00L</td>
<td>Spatial Planning and Landscape Development</td>
<td>W</td>
<td>5</td>
<td>4G</td>
<td>G. Debrunner, S. Hauller, D. Jerjen</td>
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</table>

**Abstract**

**Objective**

**Content**

**Lecture notes**

**Prerequisites / notice**

**Competencies**

**Method-specific Competencies**

**Social Competencies**

**Personnel Competencies**

**Literature**


https://doi.org/10.1007/978-3-031-49014-9

### Environment and Water

#### 651-3561-00L Cryosphere

**Abstract**
The course introduces the different components of the cryosphere - snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their respective roles in the climate system. For each subsystem, essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.

**Objective**
Students are able to
- qualitatively explain relevant processes, feedbacks and relationships between the different components of the cryosphere,
- quantify and interpret physical processes, which determine the state of the cryospheric components, with simple calculations.

In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

**Content**
The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, permafrost, and their roles in the climate system. Essential physical aspects are emphasized for each subsystem: e.g. the material properties of ice, mass balance and dynamics of glaciers, or the energy balance of sea ice.

**Lecture notes**
Handouts will be distributed during the teaching semester

**Literature**

Further literature will be indicated during the lecture.

#### 701-0479-00L Environmental Fluid Dynamics

**Abstract**
This course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.

**Objective**
Students are able to
- to name the basics, concepts and methods of environmental fluid dynamics,
- to understand and discuss the components of the basic physical equations
- to mathematically solve basic equations for simple problems of environmental fluid dynamics.

The competencies of process understanding and system understanding are taught, applied and examined.

**Content**
Basic physical terminology and mathematical laws:
Continuum hypothesis, forces, constitutive laws, state equations and basic principles of thermodynamics, kinematics, laws of mass and momentum on rotating earth.
Concepts and illustrative flow systems: vorticity dynamics, boundary layers, instability, turbulence - with respect to environmental fluid systems.
Scale analysis: dimensional variables and dynamical similarity, simplification of the fluid system, e.g. shallow water assumption, geostrophic flow.
Waves in environmental fluid systems.

**Lecture notes**
In english language

**Literature**
Will be presented in class.
See also: web-site.
This course conveys the basics of forest ecology with an emphasis on trees as those organisms that dominate the physiognomy and the dynamics of forest ecosystems. Based on this course, students have a good grasp of the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with a focus on central Europe.

Students are able to:
- summarize the fundamentals of forest ecology at the autecological, demecological and synecological level
- explain how trees dominate the physiognomy and dynamics of forest ecosystems
- describe the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with an emphasis on central Europe and Alpine region.

Overall, the competences of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught and examined in this course.

Introduction and overview of the forests of the world
Forest ecosystem ecology: Production ecology of forests
Autecology: light, temperature, wind, water, and nutrients
Demecology: regeneration ecology, forest growth, mortality
Synecology: fundamentals of trophic interactions (forest-ungulate interactions), succession

Handouts are available for download from https://fe.ethz.ch/studium/lehrmaterialien/bachelor/waldoekologie.html.


The contents of the following courses of the 2nd year of the USYS BSc are required:
- Pedosphere, Hydrosphere, Fundamentals of biology and ecology, Introduction to dendrology (knowledge of European tree species).

In the course "Atmosphere", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined.

Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Students are able to:
- to explain the physical structure and chemical composition of the atmosphere
- to quantitatively describe and understand the fundamental physical and chemical process in the atmosphere
- to explain the interactions and feedbacks between atmosphere - ocean - land surface, troposphere - stratosphere and weather - climate.

In the course "Atmospheric Physics", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined.

This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, especially prediction of showers and severe convective storms, and optical phenomena.

Students are able to:
- to explain the mechanisms of convective storm formation using knowledge of thermodynamics and cloud microphysics.
- to interpret precipitation radar images
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

In the course "Atmospheric Physics", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined. Measurement methods are taught as well.
Content
The course starts with introducing selected concepts of thermodynamics for atmospheric processes; The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to use thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in radiosonde ascents. Atmospheric mixing processes are introduced as a basis for fog formation. The concept of an air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Lecture notes
Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=22731

An electronic version of this book can be obtained via the ETH library.

pdf-files of the revised book will be provided on moodle on a chapter-by-chapter basis.

Prerequisites / notice
We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

Content
Physical Groundlagen: Schall, Wellen, Quellenarten.
Akustische Messtechnik: Umgang mit Dezibel, Akustische Masse, Schalpegellmesser, Spektralanalyse.
Lärmwirkungen: Gehör, Gesundheitliche Wirkungen von Lärm, Störung, Belästigung, Belastungs masse.
Lärmprognoseverfahren: Messen/Berechnen, Strassens, Eisenbahnlärm, Fluglärm, Schiesslärm, Industrielärm.
Kurze Einführung in die Bauakustik und in die einfachsten Grundlagen der Raumakustik.
Eigenschaften von Schallquellen: Akustische Beschreibung von Schallquellen, Lärmminimierung an der Quelle.
Lärmmassen und Prognoseverfahren: Messen/Berechnen, Strassens, Eisenbahnlärm, Flugdämmung, Schiesslärm, Industrielärm.

Objective
The students will understand the basics of noise abatement: acoustics, impact of noise, measurement techniques and legislation. The students will be able to analyze different noise problems and will be able to solve simple problems of noise abatement.

In the course "Noise Abatement", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

Methods are taught, applied and examined. System understanding is taught and examined.

Methods and Technologies
Aspects of noise abatement are taught, examined. System understanding is taught and examined.

Personal Competencies
Communication
Critical Thinking
Self-direction and Self-management

Subject-specific Competencies
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving

Social Competencies
Communication

Personal Competencies
Critical Thinking
Self-direction and Self-management

Competencies
Subject-specific Competencies
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving

Social Competencies
Communication

Personal Competencies
Critical Thinking
Self-direction and Self-management

Content
The practice of landfilling, remediation of polluted sites and the disposal of radioactive waste are based on the same concepts of environmental protection. Understanding the contaminants behaviour and how to reduce their release to the environment is the key to remediating polluted sites and designing multi-barrier systems.

Objective
On successful completion of this course students will be able to:
- Describe the technologies available to minimise environmental contamination
- Describe the principles of dealing with polluted sites and propose and evaluate appropriate remediation techniques
- Explain the concepts underlying radioactive waste management practices.

Content
This lecture course consists of lectures with exercises and case studies.
- An overview of the principles of environmental protection in waste management and how this is applied in legislation.
- An overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes controlling mobility of heavy metals and organic compounds
- Introduction to contaminant transport in porous adsorbing media
- Design and function of engineered barriers. Clay as a barrier.
- Polluted site remediation: Site investigation, assessment, and remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

Prerequisites / notice
There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

Lecture notes
Skript "Lärmbekämpfung" als PDF ab Beginn der Vorlesung verfügbar.

Number
101-0339-00L

Title
Environmental Geotechnics – Polluted Sites and Waste Disposal

Type
W

ECTS
3

Hours
2G

Lecturers
M. Plötze

Autumn Semester 2024

Data: 02.07.2024 12:39

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## Pedosphere

**Number** 701-0501-00L  
**Title** Pedosphere  
**Type** W  
**ECTS** 3  
**Hours** 2V  
**Lecturers** R. Kretzschmar

**Abstract**  
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.

**Objective**  
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

**Content**  
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.

**Lecture notes** Polybook

**Literature**  

**Prerequisites / notice**  
Prerequisites: Basic knowledge in chemistry, biology and geology.

**Competencies**  
- **Subject-specific Competencies**  
  - Concepts and Theories  
  - Techniques and Technologies
- **Method-specific Competencies**  
  - Analytical Competencies  
  - Decision-making  
  - Problem-solving  
  - Project Management
- **Social Competencies**  
  - Communication
- **Personal Competencies**  
  - Adaptability and Flexibility  
  - Negotiation  
  - Integrity and Work Ethics  
  - Self-awareness and Self-reflection  
  - Self-direction and Self-management

## Soil and Water Chemistry

**Number** 701-0533-00L  
**Title** Soil and Water Chemistry  
**Type** W  
**ECTS** 3  
**Hours** 2G  
**Lecturers** R. Kretzschmar, D. I. Christl, L. Winkel

**Abstract**  
This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples.

**Objective**  
1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants.  
2. Quantitative applications of chemical equilibria to processes in natural systems.

**Content**  
Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.

**Lecture notes** Lecture slides on Moodle

**Literature**  
- Chapters 1, 3, 4, 6, 7 and 11 in Sigg/Stumm – Aquatische Chemie, 6. Auflage, vdf, 2016.  

**Prerequisites / notice**  
The lecture courses Pedosphere and Hydrosphere are highly recommended.

**Competencies**  
- **Subject-specific Competencies**  
  - Concepts and Theories  
  - Techniques and Technologies
- **Method-specific Competencies**  
  - Analytical Competencies  
  - Problem-solving
- **Social Competencies**  
  - Communication
- **Personal Competencies**  
  - Critical Thinking

### Renewable Energies

#### Number 151-1633-00L  
**Title** Energy Conversion  
**Type** W  
**ECTS** 4  
**Hours** 3G  
**Lecturers** I. Karlin, G. Sansavini, S. A. Hosseini

**Abstract**  
This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.
In the course "Energy Conversion", the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

### Objective
Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course is to give a compact introduction into basics of Thermodynamics: Thermodynamic states and thermodynamic processes; Work and Heat; First and Second Laws of Thermodynamics. Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to building up students‘ intuition about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibrium. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included.

In the course "Energy Conversion", the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

### Content
1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

### Lecture notes
Lecture slides and supplementary documentation will be available online.

### Literature

Note: This course is intended for students outside of D-MAVT.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

#### Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

#### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Prerequisites / notice
Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.

### Course Information

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>102-0000-10L</td>
<td>Excursions for Environmental Engineers I</td>
<td>W</td>
<td>1</td>
<td></td>
<td>J. Wang, further lecturers</td>
</tr>
</tbody>
</table>

### Excursions of Subject-specific electives

#### Excursions for Environmental Engineers I
No registration through myStudies. The registration for excursions and field courses goes through http://exkursionen.umwelteng.ethz.ch/ only.

### Abstract
Half-day to one-day excursions as a supplement to the environmental engineering lectures.
Objective
As a supplement to the environmental engineering-specific lectures, the professorships offer half-day to one-day excursions in various subject areas. During the excursions, the students deepen the specialist knowledge acquired in the lectures and self-study and establish a link to practice and research. These excursions are open to all Bachelor's students of Environmental Engineering, depending on availability, and can be assessed with credit points as part of the subject-specific electives. The excursions are voluntary and should preferably be attended from the 4th semester onwards.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
102-0000-20L | Excursions for Environmental Engineers II | W | 1 credit | J. Wang, further lecturers

Abstract
Half-day to one-day excursions as a supplement to the environmental engineering lectures.

Objective
As a supplement to the environmental engineering-specific lectures, the professorships offer half-day to one-day excursions in various subject areas. During the excursions, the students deepen the specialist knowledge acquired in the lectures and self-study and establish a link to practice and research. These excursions are open to all Bachelor's students of Environmental Engineering, depending on availability, and can be assessed with credit points as part of the subject-specific electives. The excursions are voluntary and should preferably be attended from the 4th semester onwards.

Additional Compulsory Courses

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---

Abstract
The course is organized in the form of seminars held by the students. Topics selected from the core disciplines of the curriculum (water resources, urban water engineering, material fluxes, waste technology, air pollution, earth observation) are discussed in the class on the basis of scientific papers that are illustrated and critically reviewed by the students.

Objective
Learn about recent research results in environmental engineering and analyse practical applications in environmental engineering.

Competencies
Subject-specific Competencies
- Concepts and Theories: fostered
Method-specific Competencies
- Media and Digital Technologies: fostered
Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Self-presentation and Social Influence: fostered
Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: fostered
- Self-awareness and Self-reflection: fostered

Electives
The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

Electives ETH Zurich

Course Catalogue of ETH Zurich

Science in Perspective

Recommended Science in Perspective (Type B) for D-BAUG

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Bachelor's Thesis

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
102-0000-00L | Bachelor's Thesis | O | 10 credits | 21D | Supervisors

Abstract
The Bachelor Programme concludes with the Bachelor Thesis. This project is supervised by a professor. Writing up the Bachelor Thesis encourages students to show independence and to produce structured work.

Objective
The contents base upon the fundamentals of the Bachelor Programme. Students can choose from different subjects and tasks. The thesis consists of both a written report and an oral presentation.

Environmental Engineering Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tr>
<td>Z</td>
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<td>Dr</td>
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<td>G</td>
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<td>D</td>
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<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Environmental Engineering Master

► Majors

►► Major Urban Water Management

►►► Ecological System Design

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<th>Lecturers</th>
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**Abstract**
This course deepens students’ knowledge of environmental, economic, and social assessment methodologies and their various applications.

**Objective**
This course has the aim of deepening students’ knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

In the course element "Implementation of Environmental and other Sustainability Goals", students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- demonstrate life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management

Content
Part I (Advanced Environmental Assessments)
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multiooutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment: waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of 'Continuous Improvement'
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small excercises related to course issues.

**Lecture notes**
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on Ilias

**Literature**
Will be made available.

**Prerequisites / notice**
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment, CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5,2)).

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
- Personal Competencies
  - Creative Thinking assessed
  - Critical Thinking assessed

102-0317-03L | Advanced Environmental Assessment (Computer Lab) | O    | 1    | 1U    | S. Pfister |

**Abstract**
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice

**Objective**
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.

**Competencies**
- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
- Personal Competencies
  - Critical Thinking assessed

►►► Process Engineering in Urban Water Management

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2385 of 2667
Title: System Analysis in Urban Water Management

<table>
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<tr>
<th>Number</th>
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<tr>
<td>102-0227-00L</td>
<td>Systems Analysis and Mathematical Modeling in Urban Water Management</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>E. Morgenroth, M. Maurer</td>
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Objective: The goal of this course is to provide the students with an understanding of how urban water system can be described with mathematical models, and give them the to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

Content: The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

Lecture notes: Copies of handouts will be available digitally.

Literature: There will be a required textbook that students need to purchase:
Willi Gujer (Ed.): Systems Analysis for Water Technology. Springer-Verlag, Berlin Heidelberg

Prerequisites / notice: Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel to the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Critical Thinking
- Self-direction and Self-management

Title: Process Engineering Ia

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<td>Process Engineering Ia</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>E. Morgenroth</td>
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</table>

Abstract: Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective: Students should be able to evaluate and design biological processes.

Content:
- Stoichiometry
- Microbial transformation processes
- Introduction to design and modeling of activated sludge processes
- Anaerobic processes, industrial applications, sludge stabilization

Literature: There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice: For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be accessed via http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Customer Orientation

Personal Competencies
- Critical Thinking

Title: Water Infrastructure Planning and Stormwater Management

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<tr>
<th>Number</th>
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<td>Urban Drainage Planning and Modelling</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>M. Maurer, U. Kaura, J. P. Leitão Correia, M. Stähle</td>
</tr>
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</table>

Abstract: In this course, students learn modern urban drainage engineering approaches, critical thinking, decision making in a complex environment as well as dealing with insufficient data and ill-defined problems.

Objective: By the end of the course, you should be able to do the following:
- Apply different methods and methodologies to assess the impact of urban drainage on water pollution and flooding potential.
- Distinguish between hydrological and hydrodynamic models and their correct application.
- Identify the difference between emission and immission oriented approaches for identifying drainage measures.
- Identify relevant measures, quantify their effects and assess their relative ranking/priority.
- Consider uncertainties and handle incomplete data and information.
- Make decisions and recommendations in a complex application case.
- Teamwork. State principles of effective team performance and the functions of different team roles; work effectively in problem-solving teams.
- Communication. Communicate and document your findings in concise group presentations and a written report.
In urban drainage, the complexity of the decision-making, the available methodologies and the data availability have increased significantly. In current environmental engineering practice, the focus has shifted from tables and nomograms to sophisticated simulation tools. The topics cover:
- Integrated urban water management
- Hydrological and hydrodynamic modelling
- Water quality based assessment
- Freshwater ecology
- Hydraulic capacity assessment
- Sewer network operation
- Decision analysis

Prerequisites / notice
Prerequisites: 102-0214-00 Siedlungswasserwirtschaft and 102-0215-00 Siedlungswasserwirtschaft II or comparable educational background.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation fostered

Personal Competencies
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking assessed
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

Major Environmental Technologies
Air Quality Control

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<tr>
<th>Number</th>
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<td>102-0377-00L</td>
<td>Air Pollution Modeling and Chemistry</td>
<td>O</td>
<td>3 credits</td>
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<td>S. Henne, S. Reimann Bhend, J. Tang</td>
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Abstract
Air pollutants cause negative effects on humans, wildlife and buildings. To control and reduce the impact of air pollutants, their transfer from sources to receptors needs to be known. This transfer includes transport within the atmospheric boundary layer, chemical transformation reactions and phase-transfer processes from gases to particles.

Objective
The students understand the fundamental principles of atmospheric transport, dispersion and chemistry of pollutants on the local to regional scale and their transfer gas to particle phases (secondary aerosols). This includes the knowledge of important atmospheric reactions, sources and sinks. The obtained understanding enables the students to apply computational tools to predict the transport and transformation of chemicals at the local to regional scale.

Content
- Structure of the Atmosphere
- Thermodynamics of the atmosphere
- Atmospheric stability
- Atmospheric boundary layer and turbulence
- Dispersion in the atmospheric boundary layer
- Numerical models of atmospheric dispersion
- Gas phase reaction kinetics
- Tropospheric chemistry and ozone formation
- Chemistry box models
- Volatile organic pollutants (VOCs) and semi-volatile organic pollutants (SVOCs)
- Aerosol modelling
- Air pollution source apportionment
- Inverse modelling of emissions

Lecture notes
Continued updates of:
- Slides and handouts
- Home assignments and sample solutions
- R package and code for some of the home assignments
- MATLAB codes
- Key journal articles as discussed during lecture

Literature
Atmospheric chemistry


Environmental organic chemistry and mass transfer
Mackay D., Multimedia environmental models : the fugacity approach; Boca Raton, Fla. : Lewis Publishers; 2001; 2nd ed

Atmospheric dynamics and boundary layer

Atmospheric modelling

Introduction to R
Process Engineering in Urban Water Management

No courses in autumn semester (HS), only in spring semester (FS).

System Analysis in Urban Water Management

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<td>Systematic introduction of material balances, transport processes (kinetics, stoichiometry and conservation), ideal reactors, residence time distribution, heterogeneous systems, dynamic response of reactors, parameter identification, local sensitivity, error propagation, and Monte Carlo simulations. Introduction to real-time control (PID controllers). Extensive numerical simulations with coding.</td>
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<td>- Introduction to process control (PID controller, fuzzy control)</td>
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| Literature | Copies of handouts will be available digitally. |
|PRE | There will be a required textbook that students need to purchase: Willi Gujer (2008): Systems Analysis for Water Technology. Springer-Verlag, Berlin Heidelberg |

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<td>E. Morgenroth</td>
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<td>Abstract</td>
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<td>Stoichiometry</td>
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<td>Microbial transformation processes</td>
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<td>Introduction to design and modeling of activated sludge processes</td>
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<td>Anaerobic processes, industrial applications, sludge stabilization</td>
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<td>There will be a textbook that students need to purchase: (see <a href="http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html">http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html</a> for further information).</td>
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<td>Prequisites</td>
<td>For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be accessed via <a href="http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html">http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html</a>.</td>
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<tr>
<td>102-0357-00L</td>
<td>Waste Recycling Technologies</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>M. Haupt, V. Burg</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only now just catching on in emerging markets as well.</td>
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<td>At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.</td>
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Introduction

Waste Recycling: Scope and objectives

Waste recycling technologies in Switzerland

Fundamentals

Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials

Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles

Flow sheet basics: Balancing mass flows

Standard processes: batch vs. continuous

Assessment of separation success: Separation function; grade vs. recovery

Separation Processes

Separation according to size and shape (Classification): Screening, Flow separation

Separation according to material properties (Concentration): Manual Sorting, Gravity concentration; Magnetic separation, Eddy current separation, Electrostatic separation, Sensor technology; Froth flotation

Lecture notes

The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Literature

A list of recommended books will be provided.

Prerequisites / notice

The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

102-0217-00L

Process Engineering Ia

Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective

Students should be able to evaluate and design biological processes.

Content

Stoichiometry

Microbial transformation processes

Introduction to design and modeling of activated sludge processes

Anaerobic processes, industrial applications, sludge stabilization

Literature

There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice

For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be accessed via http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Problem-solving

Social Competencies

Communication

Customer Orientation

Personal Competencies

Critical Thinking

Environmental Geotechnics – Polluted Sites and Waste Disposal

The practice of landfiling, remediation of polluted sites and the disposal of radioactive waste are based on the same concepts of environmental protection. Understanding the contaminants behaviour and how to reduce their release to the environment is the key to remediating polluted sites and designing multi-barrier systems.

Objective

On successful completion of this course students will be able to

- Assess the risk to the environment from landfills, contaminated sites and radioactive waste repositories in terms of the fate and transport of contaminants.
- Describe the technologies available to minimise environmental contamination
- Describe the principles of dealing with polluted sites and propose and evaluate appropriate remediation techniques
- Explain the concepts underlying radioactive waste management practices.

Content

This lecture course consists of lectures with exercises and case studies.
- An overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes controlling mobility of heavy metals and organic compounds
- Introduction to contaminant transport in porous adsorbing media
- Design and function of engineered barriers. Clay as a barrier.
- Polluted site remediation: Site investigation, assessment, and remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

Prerequisites / notice

excursion

Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management
This course has the aim of deepening students' knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

In the course element "Implementation of Environmental and other Sustainability Goals", students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- demonstrate life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management

Content
Part I (Advanced Environmental Assessments)
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multoutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of 'Continuous Improvement'
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management
- Students will get small exercises related to course issues.

Lecture notes
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on Ilias

Literature
Will be made available.

Prerequisites / notice
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5,2)).

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed

102-0317-03L Advanced Environmental Assessment (Computer Lab) O 1 credit 1U S. Pfister

Abstract
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice

Objective
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed

Personal Competencies
- Critical Thinking assessed

Module is offered in Spring Semester.
Introduction
The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Lecture notes
The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Literature
A list of recommended books will be provided.

Objective
At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.

Content
Introduction
Waste Recycling: Scope and objectives
Waste recycling technologies in Switzerland
Fundamentals
Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials
Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
Flow sheet basics: Balancing mass flows
Standard processes: batch vs. continuous
Assessment of separation success: Separation function; grade vs. recovery

Separation Processes
Separation according to size and shape (Classification): Screening, Flow separation
Separation according to material properties (Concentration): Manual Sorting, Gravity concentration; Magnetic separation, Eddy current separation, Electrostatic separation, Sensor technology, Froth flotation

Assessment of separation success: Separation function; grade vs. recovery

Lecture notes
The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Literature
A list of recommended books will be provided.

Prerequisites / notice
The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

102-0217-00L Process Engineering Ia

Abstract
Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective
Students should be able to evaluate and design biological processes.

Content
Stoichiometry
Microbial transformation processes
Introduction to design and modeling of activated sludge processes
Anaerobic processes, industrial applications, sludge stabilization

Literature
There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice
For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be accessed via http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Social Competencies
Communication
Customer Orientation

Personal Competencies
Critical Thinking

Waste Recycling Technologies

Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

Objective
At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.

Content
Introduction
Waste Recycling: Scope and objectives
Waste recycling technologies in Switzerland
Fundamentals
Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials
Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
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Standard processes: batch vs. continuous
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Assessment of separation success: Separation function; grade vs. recovery

Lecture notes
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Literature
A list of recommended books will be provided.

Prerequisites / notice
The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

102-0217-00L Process Engineering Ia

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Objective
Students should be able to evaluate and design biological processes.

Content
Stoichiometry
Microbial transformation processes
Introduction to design and modeling of activated sludge processes
Anaerobic processes, industrial applications, sludge stabilization

Literature
There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

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Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Social Competencies
Communication
Customer Orientation

Personal Competencies
Critical Thinking

101-0339-00L Environmental Geotechnics – Polluted Sites and Waste Disposal

Abstract
The practice of landfiling, remediation of polluted sites and the disposal of radioactive waste are based on the same concepts of environmental protection. Understanding the contaminants behaviour and how to reduce their release to the environment is the key to remediating polluted sites and designing multi-barrier systems.

Objective
On successful completion of this course students will be able to
- Assess the risk to the environment from landfills, contaminated sites and radioactive waste repositories in terms of the fate and transport of contaminants.
- Describe the technologies available to minimise environmental contamination
- Describe the principles of dealing with polluted sites and propose and evaluate appropriate remediation techniques
- Explain the concepts underlying radioactive waste management practices.

Content
This lecture course consists of lectures with exercises and case studies.
- An overview of the principles of environmental protection in waste management and how this is applied in legislation.
- An overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material_RADIOACTIVE waste repository focusing on processes controlling mobility of heavy metals and organic compounds
- Introduction to contaminant transport in porous adsorbing media
- Design and function of engineered barriers. Clay as a barrier
- Polluted site remediation: Site investigation, assessment, and remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

Prerequisites / notice
- Excursion
### Water Resources Management

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>102-0468-10L</td>
<td>Watershed Modelling</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>P. Molnar, A. Costa, S. Sinclair</td>
</tr>
</tbody>
</table>

**Abstract**

Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

**Objective**

The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

**Content**

The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn to use GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

**Lecture notes**

There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

**Literature**

Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

**Prerequisites / notice**

Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences). Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

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<td>Decision-making</td>
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<td>Problem-solving</td>
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**Social Competencies**

- Communication fostered
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Negotiation fostered

**Personal Competencies**

- Adaptability and Flexibility fostered
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

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### Major Water Resources Management

#### Flow and Transport

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>101-0267-01L</td>
<td>Numerical Hydraulics</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>E. Secchi, D. Vanzo</td>
</tr>
</tbody>
</table>

**Abstract**

In the course Numerical Hydraulics the basics of numerical modelling of flows are presented.

**Objective**

The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.

**Content**

The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

**Lecture notes**

Slides from the lectures and programs used can be downloaded.

**Literature**

Given in lecture
Competencies | Subject-specific Competencies | Concepts and Theories | assessed  
|------------------|-------------------------|-------------------| 
| Method-specific Competencies | Analytical Competencies | assessed  
| Decision-making | Problem-solving | assessed  
| Social Competencies | Communication | fostered  
| Cooperation and Teamwork | fostered  
| Personal Competencies | Critical Thinking | assessed  
| Integrity and Work Ethics | fostered  

102-0259-00L | Ecohydraulics and Habitat Modelling | O | 3 credits | 2G | R. Stocker, K.-D. Jorde, L. G. Martins da Silva, A. Siviglia

Abstract
At a time in which humans have significantly affected the natural environment and yet society increasingly values the many services of natural ecosystems, accounting for ecological processes in engineering design is a major contemporary challenge for environmental and civil engineers.

Objective
This is the fundamental topic in ecohydraulics, the discipline that focuses on the consequences of fluid flow and related physical processes on the organisms that inhabit aquatic environments. While still a young science, ecohydraulics already endows the engineer with an overall understanding and quantitative tools to predict how physical processes shape habitat quality and quantity, enabling the analysis of different management options for natural and man-made water bodies in terms of their ecosystem consequences.

Content
This class will take a broad view of ecohydraulics and introduce students to key concepts in aquatic habitat modeling. Recognizing that an ecosystem is composed of diverse organisms with different seasonal habitat requirements across a range of scales, the class will focus on multiple representative groups of organisms, including fish, macroinvertebrates, plankton, and vegetation. The lectures will build on the students' knowledge of hydraulics, to give them both an appreciation for the dependence of organisms on their physical environment and a set of quantitative modeling approaches that they can take with them into engineering practice, in fields ranging from hydropower development and upgrade, to reservoir operation, river restoration, flood protection, water management and beyond. At the broadest scale, this class will contribute to the students’ appreciation of the tight link between the natural and the built or impacted environment, and of the imperatives of considering both in the design process.

Competencies
Subject-specific Competencies | Concepts and Theories | assessed  
|------------------|-------------------------| 
| Method-specific Competencies | Analytical Competencies | fostered  
| Problem-solving | fostered  
| Personal Competencies | Critical Thinking | assessed  
| Integrity and Work Ethics | fostered  

Module is offered in Spring Semester.

Landscape Planning and Environmental Systems L

Number | Title | Type | ECTS | Hours | Lecturers | 
|---|---|---|---|---|---| 
| 103-0347-00L | Landscape Planning and Environmental Systems | O | 3 credits | 2V | A. Grêt-Regamey

Abstract
In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

Objective
The aims of this course are:
1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.

Content
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Lecture notes
No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites / notice
The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.
The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

**Objective**
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on the hydrology-sediment connections at the field and catchment scale. The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

**Content**
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-riparian gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

**Lecture notes**
There is no script.

**Literature**
The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.
Major River and Hydraulic Engineering

Flow and Transport

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Hydraulic Engineering

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<tr>
<td>101-0247-01L</td>
<td>Hydraulic Engineering II</td>
<td>O</td>
<td>6 credits</td>
<td>4G</td>
<td>R. Boes</td>
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<tr>
<td>Abstract</td>
<td>Information: Enrolment of Hydraulic Engineering II is not recommended without having attended Hydraulic Engineering (101-0206-00L) previously since Hydraulic Engineering II is strongly based on Hydraulic Engineering (101-0206-00L).</td>
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<tr>
<td>Objective</td>
<td>Knowledge of hydraulic structures and their functions within hydraulic systems. Skills for the layout and design of hydraulic structures with regard to economy and safety.</td>
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River Systems

Objective
At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river;
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content
The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river rehabilitation project at the Alpine Rhine in Austria and Switzerland.

Prerequisites / notice
Recommended lectures: Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving
Social Competencies
Communication
Cooperation and Teamwork
Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Self-direction and Self-management

Lecturers
V. Wirzbach, I. Schalko, K. Sperger

Number Title Type ECTS Hours Lecturers
101-0258-00L River Engineering O 3 credits 2G V. Wirzbach, I. Schalko, K. Sperger

Abstract
The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

Prerequisites / notice
Information: Because Hydraulic Engineering II is strongly based on Hydraulic Engineering (Wasserbau, 101-0206-00L) it is strongly recommended to have taken this course (101-0206-00L) or a similar one previously.

Literature
Lecture notes 
1. Erosion and Sedimentation; Pierre Y. Julien
2. River Mechanics; Pierre Y. Julien

Literature and further documentation is specified in the lecture and in the manuscript

Course contents
Weirs: Weir stability, gates, inflatable dams, appurtenant structures, fish up- and downstream passages.
Conduits: Design of headraces, pressure shafts, and penstocks, structural details and construction.
Hydropower plants: Powerhouse and turbine types, design, functionality, construction processes.
Dams: Types, appurtenant structures (river diversion, spillways, bottom and low-level outlets), dam type selection criteria, layout and design of gravity dams, buttress dams, arch dams, rockfill dams with central core or concrete face, reservoir sedimentation and sediment management, dam surveillance.
Artificial reservoirs: Purpose, layout, sealing, appurtenant structures, environmental aspects.
Economical aspects of hydraulic infrastructure

Number Title Type ECTS Hours Lecturers
102-0287-00L River Basin Erosion O 3 credits 2G P. Molnar

Abstract
The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

Objective
The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

Remark: partly in German.

Data: 02.07.2024 12:39
Autumn Semester 2024
Page 2396 of 2667
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

The project work is supervised by a professor. Students can choose from different subjects and tasks. The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on the course webpage.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2397 of 2667
Content
- Structure of the Atmosphere
- Thermodynamics of the atmosphere
- Atmospheric stability
- Atmospheric boundary layer and turbulence
- Dispersion in the atmospheric boundary layer
- Numerical models of atmospheric dispersion
- Gas phase reaction kinetics
- Tropospheric chemistry and ozone formation
- Chemistry box models
- Volatile organic pollutants (VOCs) and semi-volatile organic pollutants (SVOCs)
- Aerosol modelling
- Air pollution source apportionment
- Inverse modelling of emissions

Lecture notes
Continued updates of:
- Slides and handouts
- Home assignments and sample solutions
- R package and code for some of the home assignments
- MATLAB codes
- Key journal articles as discussed during lecture

Literature
Atmospheric chemistry

Environmental organic chemistry and mass transfer
Mackay D., Multimedia environmental models : the fugacity approach; Boca Raton, Fla.: Lewis Publishers; 2001; 2nd ed

Atmospheric dynamics and boundary layer

Atmospheric modelling

Introduction to R

Prerequisites / notice
strongly recommended: 102-0635-01L Luftreinhaltung (Air Pollution Control) or similar

EM: Ecological Systems Design
Elective Module for Majors "Environmental Technologies", "River and Hydraulic Engineering" and "Water Resources Management".

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<tr>
<td>102-0307-01L</td>
<td>Advanced Environmental, Social and Economic Assessments</td>
<td>W</td>
<td>5 credits</td>
<td>4G</td>
<td>A. E. Braunschweig, S. Pfister, A. Kim</td>
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</table>

Abstract
This course deepens students' knowledge of environmental, economic, and social assessment methodologies and their various applications.

Objective
This course has the aim of deepening students' knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

In the course element "Implementation of Environmental and other Sustainability Goals", students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including ‘organisational LCA’ (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- demonstrate life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management
Content
Part I (Advanced Environmental Assessments)
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multiooutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of ‘Continuous Improvement’
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including ‘organisational LCA’ (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small exercises related to course issues.

Lecture notes
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on ilias

Literature

Prerequisites / notice
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5,2)).

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

102-0317-03L Advanced Environmental Assessment (Computer Lab) W 1 credit 1U S. Pfister

Abstract
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice

Objective
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Personal Competencies
Critical Thinking assessed

101-0267-01L Numerical Hydraulics W 3 credits 2G E. Secchi, D. Vanzo

Abstract
In the course Numerical Hydraulics the basics of numerical modelling of flows are presented.

Objective
The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.

Content
The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

Lecture notes
Slides from the lectures and programs used can be downloaded.

Literature
Given in lecture

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Critical Thinking assessed
Integrity and Work Ethics fostered

102-0259-00L Ecohydraulics and Habitat Modelling W 3 credits 2G R. Stocker, K.-D. Jorde,
**Abstract**
At a time in which humans have significantly affected the natural environment and yet society increasingly values the many services of natural ecosystems, accounting for ecological processes in engineering design is a major contemporary challenge for environmental and civil engineers.

**Objective**
This is the fundamental topic in ecohydraulics, the discipline that focuses on the consequences of fluid flow and related physical processes on the organisms that inhabit aquatic environments. While still a young science, ecohydraulics already endows the engineer with an overall understanding and quantitative tools to predict how physical processes shape habitat quality and quantity, enabling the analysis of different management options for natural and man-made water bodies in terms of their ecosystem consequences.

**Content**
This class will take a broad view of ecohydraulics and introduce students to key concepts in aquatic habitat modeling. Recognizing that an ecosystem is composed of diverse organisms with different seasonal habitat requirements across a range of scales, the class will focus on multiple representative groups of organisms, including fish, macroinvertebrates, vegetation, and riparian plants. The lectures will build on the students' knowledge of hydraulics, to give them both an appreciation for the dependence of organisms on their physical environment and a set of modeling approaches that they can take with them into engineering practice, in fields ranging from hydropower development and upgrade, to reservoir operation, river restoration, flood protection, water management and beyond. At the broadest scale, this class will contribute to the students' appreciation of the tight link between the natural and the built or impacted environment, and of the imperatives of considering both in the design process.

**Competencies**
- Subject-specific Competencies: Concepts and Theories (assessed)
- Method-specific Competencies: Analytical Competencies (fostered), Decision-making (assessed), Problem-solving (assessed)
- Personal Competencies: Critical Thinking (fostered), Self-direction and Self-management (fostered)

**EM: Groundwater**
**Elective Module for Majors** "Environmental Technologies", "River and Hydraulic Engineering" and "Urban Water Management".

**EM: Hydraulic Engineering**

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<tr>
<td>101-0247-01L</td>
<td>Hydraulic Engineering II</td>
<td>W</td>
<td>6</td>
<td>4</td>
<td>R. Boes</td>
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**Abstract**
Hydraulic structures and their functions within hydraulic systems are treated in this lecture. The basic concepts of their layout and design with regard to economy and safety are provided.

**Objective**
Knowledge of hydraulic structures and their functions within hydraulic systems. Skills for the layout and design of hydraulic structures with regard to economy and safety.

**Content**
Weirs: Weir stability, gates, inflatable dams, appurtenant structures, fish up- and downstream passages.
Conduits: Design of headraces, pressure shafts, and penstocks, structural details and construction.
Hydropower plants: Powerhouse and turbine types, design, functionality, construction processes.
Dams: Types, appurtenant structures (river diversion, spillways, bottom and low-level outlets), dam type selection criteria, layout and design of gravity dams, buttress dams, arch dams, rockfill dams with central core or concrete face, reservoir sedimentation and sediment management, dam surveillance.
Artificial reservoirs: Purpose, layout, sealing, appurtenant structures, environmental aspects.
Economical aspects of hydraulic infrastructure

**Lecture notes**
manuscript and further documentation

**Literature**
is specified in the lecture and in the manuscript

**Prerequisites / notice**
Information: Because Hydraulic Engineering II is strongly based on Hydraulic Engineering (Wasserbau, 101-0206-00L) it is strongly recommended to have taken this course (101-0206-00L) or a similar one previously.

**Competencies**
- Subject-specific Competencies: Concepts and Theories (assessed)
- Method-specific Competencies: Analytical Competencies (assessed), Decision-making (assessed), Problem-solving (assessed)
- Personal Competencies: Adaptability and Flexibility (fostered), Creative Thinking (fostered), Critical Thinking (fostered), Self-direction and Self-management (fostered)

**EM: Landscape**
**Elective Module for Majors** "Environmental Technologies", "Resource Management", "River and Hydraulic Engineering" and "Urban Water Management".

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<tr>
<td>103-0347-00L</td>
<td>Landscape Planning and Environmental Systems</td>
<td>W</td>
<td>3</td>
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<td>A. Grêt-Regamey</td>
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**Abstract**
In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

**Objective**
The aims of this course are:
1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, and how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

Content is on climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Lecture notes: No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites / notice: The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered
Abstract
This course provides an introduction to processing and interpreting radar and synthetic aperture radar (SAR) remote sensing data. The primary topics of the course are interferometric techniques and related applications such as topography mapping and mapping of surface displacements, with a strong emphasis on solving practical problems using MATLAB.

Objective
Understand the concepts and techniques required to process and to adequately interpret interferometric radar/SAR data for topographic mapping and surface displacement applications.

Content
The rationale behind the structure of the course follows the idea that radar imaging and radar/SAR interferometry are closely related and that a basic understanding of the radar imaging concept is helpful to understand and interpret interferometric radar data for various applications.

The course starts with the real-aperture radar case and a first introduction to the concept of radar interferometry with applications to topographic mapping and mapping of surface displacements.

Based on that, the 2-D imaging concept used in synthetic aperture radar imaging is treated. Then, we expand further on radar and SAR interferometric (InSAR) concepts and processing steps for single interferograms and stacks of interferograms also using persistent scatterer interferometry (PSI) to measure deformation based on time series of interferometric SAR data.

Finally, the 3-D radar imaging case (SAR tomography) is put into context with PSI/InSAR time series as an extension of the more classical interferometric approaches thereby closing the circle around the strongly related concepts of SAR imaging and interferometry.

Lecture notes
Lecture notes/handouts for each topic will be provided online.

Literature
Additional reading material:
ISBN: 978-0-306-47633-4
https://doi.org/10.1007/0-306-47633-9

Prerequisites
It is highly recommended that the student has previously taken the following courses:
102-0617-00L: Basics and Principles of Radar Remote Sensing
and
102-0617-01L: Methodologies for Image Processing of Remote Sensing Data

102-0617-00L Basics and Principles of Radar Remote Sensing for Environmental Applications

Abstract
The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.

Objective
The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation. At the end of the course the student has the understanding of
1. SAR basics and principles,
2. SAR polarimetry,
3. SAR interferometry and
4. environmental parameter estimation from multi-parametric SAR data

Content
The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:
1. Introduction into SAR basics and principles
2. Introduction into electromagnetic wave theory
3. Introduction into scattering theory and decomposition techniques
4. Introduction into SAR interferometry
5. Introduction into polarimetric SAR interferometry
6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

Lecture notes
Handouts for each topic will be provided

Literature
First readings for the course:
Complete literature listing will be provided during the course.

EM: River Systems

Remark: partly in German.

Note only for HS23: The previous replacement course Wildbach- und Hangverbau for River Basin Erosion will not be offered in HS23. Students taking LAND and RIVER must take one from the following list as a substitute for River Basin Erosion, which occurs in both modules:
- 101-0577-00 An Introduction to Sustainable Development in the Built Environment (HS)
- 701-1257-00 European Climate Change (HS)
- 101-1249-00 Hydraulics of Engineering Structures (HS)

Number Title Type ECTS Hours Lecturers
101-0258-00L River Engineering W 3 credits 2G V. Weitbrecht, I. Schalko, K. Sperger

Abstract
The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

Objective
At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.
The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to assess
Creative Thinking
2G
Students are able to:
1. Erosion and Sedimentation; Pierre Y. Julien
The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on
ECTS
There is no script.
Title
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change,
W
Lecture slides can be downloaded via Moodle.
Literature
1. Erosion and Sedimentation; Pierre Y. Julien
2. River Mechanics; Pierre Y. Julien
Prerequisites / notice
Recommended lectures:
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Competencies
Subject-specific Competencies
Concepts and Theories
assessed
Techniques and Technologies
assessed
Method-specific Competencies
Analytical Competencies
assessed
Decision-making
fostered
Problem-solving
assessed
Social Competencies
Communication
fostered
Cooperation and Teamwork
fostered
Personal Competencies
Creative Thinking
fostered
Critical Thinking
assessed
Self-direction and Self-management
fostered

River Basin Erosion
W
3 credits
2G
P. Molnar

Objective
The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

Content
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

There is no script.
The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice
Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

EM: Soil


Number
701-0535-00L
Title
Environmental Soil Physics/Vadose Zone Hydrology
Type
W
ECTS
3 credits
Hours
2V+1U
Lecturers
A. Caminati,
P. U. Lehmann Grunder

Abstract
The course provides theoretical and practical foundations for understanding and characterizing physical soil properties and processes and their relevance for terrestrial ecosystems, plant growth, hydrological processes and atmospheric-land gas exchange, across all relevant scales.

Objective
Students are able to:
- Characterize the different soils based on their key textural and structural properties.
- Simulate and predict soil water retention and flow under varying environmental conditions and understand the key driving forces (capillarity, gravity, friction) and related water properties (surface tension and viscosity).
- Predict soil hydraulic properties for varying soil textural classes.
- Predict solute transport in soils for varying environmental conditions.
- Predict energy balance and temperature dynamics in soils.
- Predict conditions for plant water stress.
- Estimate the impact of soil properties on the hydrological cycle and on plant growth.
INTRODUCTION
Week 1 (September 18)
Presentation of the role of soil physics in environmental sciences and terrestrial ecosystems: soils in the water cycle; soils and vegetation; soils and solute transport. Survey on students' interests and expectations. Presentation of course structure and learning objectives.

BASIC SOIL PROPERTIES
Week 2 (September 25) and Week 3 (October 02)
soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density
Pore scale consideration (water in a single pore), pore sizes and shapes; surface tension; Young-Laplace equation; capillary rise; contact angle
Friction and laminar flow; Hagen-Poiseuille's law; Washburn equation; numerical lab (REPORT 1)

SOIL HYDRAULIC PROPERTIES
Week 4 (October 09) and Week 5 (October 16)
Soil water content and soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point
Soil water characteristics and pore size distribution
Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts; effective conductivity; unsaturated hydraulic conductivity; Buckingham law.
Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications

TOOLBOX – MEASUREMENTS AND MODELING
Week 6 (October 23) and Week 7 (October 30)
Measuring soil hydraulic properties, fitting and interpretation; Lab tour - demonstration of soil physical methods; lecture on HYPROP method; report on Hyprop data (REPORT 2)
Modelling unsaturated water flow based on Richards equation - Using Hydrus1D for simulation of unsaturated flow; simulating HYPROP measurements (REPORT 3)

SOIL IN THE WATER CYCLE
Week 8 (November 06) – Week 9 (November 13)
Water infiltration - steady state solutions for infiltration; approximate solutions to infiltration (Green-Ampt, Philip); infiltration rate and ponding; outlook to preferential flow
Water evaporation - Energy balance and land atmosphere interactions - potential and actual evaporation, evaporation stages;

SOIL PLANT INTERACTIONS
Week 10 (November 20) Week 11 (November 27)
Root water uptake and transpiration – Theory and mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance.
Modelling root water uptake and transpiration; analytical approaches and modeling using Hydrus (REPORT 4)

SOLUTE TRANSPORT
Week 12 (December 04) Week 13 (December 11)
Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application
Transport of reactive substances, preferential flow, simulations with Hydrus

CLOSURE
Week 14 (December 18)
Summary, course synthesis, connections between the different topics, questions, exam preparation

Literature
Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hille

Competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Analytical Competencies assessed</td>
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<td>Adaptability and Flexibility fostered</td>
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<td>Creative Thinking fostered</td>
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Soil-Plant Water Relations

W 3 credits 2V A. Carminati

701-1343-00L

Abstract
Water limitation is a primary constraint on plant growth and terrestrial fluxes worldwide. In this course, the principles of water flow in soil and plants are discussed, with particular attention on the effect of drought on root water uptake, transpiration and plant growth. Strategies of plants to tolerate drought are discussed in relation to both agricultural and ecological implications.

Objective
The students are able to: explain and compare systematically the drivers of water stress to plants; to solve the equations of water flow in soil and plants and to calculate plant water status for varying soil and climatic conditions and plant traits; to critically review and present one research question in soil-plant water relations; to openly debate on the current trends in soil and plant water research and climate change ecology.
Part 1 - Lectures
Week 1: Introduction.
Week 2: Soil water relations; Principles of soil water retention and soil water flow; Soil hydraulic properties.
Week 3: Root water uptake; soil hydraulic constraints on transpiration
Week 4: Rhizosphere processes and properties; root-soil contact; root hairs; mycorrhiza; rhizodeposition.
Week 5: Water flow in roots and xylem; root anatomy, architecture and plasticity; cavitation.
Week 6: Transpiration; Vapor Pressure Deficit; Photosynthesis; Stomatal regulation.
Week 7: Soil-plant-atmospheric continuum; Below- and above-ground feedbacks; Soil and atmospheric drivers of transpiration losses.

Part 2 - Seminar
Week 8: Plant response to drought and consequences for agriculture and forests. Open questions and introduction to seminar topics.
Week 9: Class work - preparation of the presentations/Debate
Week 10: Class work - preparation of the presentations/Debate
Week 11: Seminar/Debate (presentations)
Week 12: Seminar/Debate (presentations)
Week 13: Seminar/Debate (presentations)
Week 14: Feedback, Summary, Conclusion

Literature
Lecture notes; selection of articles

Prerequisites / notice
Vadose Zone Hydrology/Environmental Soil Physics (recommended but not required)

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies fostered
Problem-solving fostered

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

EM: System Analysis in Urban Water Management
Elective Module for Majors “Resource Management”, “River and Hydraulic Engineering” and “Water Resources Management”.

Number Title Type ECTS Hours Lecturers
102-0227-00L Systems Analysis and Mathematical Modeling in Urban Water Management W 6 credits 4G E. Morgenroth, M. Maurer

Abstract
Systematic introduction of material balances, transport processes (kinetics, stoichiometry and conservation), ideal reactors, residence time distribution, heterogeneous systems, dynamic response of reactors, parameter identification, local sensitivity, error propagation, and Monte Carlo simulations. Introduction to real-time control (PID controllers). Extensive numerical simulations with coding.

Objective
The goal of this course is to provide the students with an understanding of how urban water system can be described with mathematical models, and give them the to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

Content
The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

Lecture notes
Copies of handouts will be available digitally.

Literature
There will be a required textbook that students need to purchase:

Prerequisites / notice
Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel to the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving fostered

Personal Competencies
Critical Thinking assessed
Self-direction and Self-management fostered

Number Title Type ECTS Hours Lecturers
102-0217-00L Process Engineering Ia W 3 credits 2G E. Morgenroth

Abstract
Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective
Students should be able to evaluate and design biological processes.

Content
Stoichiometry
Microbial transformation processes
Introduction to design and modeling of activated sludge processes
Anaerobic processes, industrial applications, sludge stabilization

Literature
There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).
#### EM: Waste Management

**Elective Module for Majors "River and Hydraulic Engineering" "Urban Water Management" and "Water Resources Management".**

**Remark:** 101-0339-00 Environmental Geotechnics – Polluted Sites and Waste Disposal only for those students also taking module "System Analysis in Urban Water Management" as replacement of 102-0217-00 Process Engineering Ia in module "Waste Management".

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<td>W</td>
<td>3 credits</td>
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<td>E. Morgenroth</td>
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</table>

**Abstract**

Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

**Objective**

Students should be able to evaluate and design biological processes.

**Content**

- Microbial transformation processes
- Introduction to design and modeling of activated sludge processes
- Anaerobic processes, industrial applications, sludge stabilization

**Literature**

There will be a textbook that students need to purchase (see [http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html](http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html) for further information).

**Prerequisites / notice**

For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be accessed via [http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html](http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html)

**Competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Social Competencies
  - Communication
- Personal Competencies
  - Critical Thinking

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<tr>
<td>102-0357-00L</td>
<td>Waste Recycling Technologies</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Haupt, V. Burg</td>
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**Abstract**

Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

**Objective**

At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.

**Content**

- Waste Recycling: Scope and objectives
- Waste recycling technologies in Switzerland
- Fundamentals
  - Properties of particles; Liberation conditions, Particle size and shape, Porosity of bulk materials
  - Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
  - Flow sheet basics: Balancing mass flows
  - Standard processes: batch vs. continuous
  - Assessment of separation success: Separation function; grade vs. recovery
- Separation Processes
  - Separation according to size and shape (Classification): Screening, Flow separation
  - Separation according to material properties (Concentration): Manual Sorting, Gravity concentration; Magnetic separation, Eddy current separation. Electrostatic separation, Sensor technology, Froth flotation

**Literature notes**

The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

**Prerequisites / notice**

The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

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<tr>
<td>101-0339-00L</td>
<td>Environmental Geotechnics – Polluted Sites and Waste Disposal</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Plötze</td>
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</table>

**Abstract**

The practice of landfiling, remediation of polluted sites and the disposal of radioactive waste are based on the same concepts of environmental protection. Understanding the contaminants behaviour and how to reduce their release to the environment is the key to remediating polluted sites and designing multi-barrier systems.

**Objective**

On successful completion of this course students will be able to
- Assess the risk to the environment from landfills, contaminated sites and radioactive waste repositories in terms of the fate and transport of contaminants.
- Describe the technologies available to minimise environmental contamination
- Describe the principles of dealing with polluted sites and propose and evaluate appropriate remediation techniques
- Explain the concepts underlying radioactive waste management practices.
Content
This lecture course consists of lectures with exercises and case studies.
- An overview of the principles of environmental protection in waste management and how this is applied in legislation.
- An overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes controlling mobility of heavy metals and organic compounds.
- Introduction to contaminant transport in porous adsorbing media.
- Design and function of engineered barriers. Clay as a barrier.
- Polluted site remediation: Site investigation, assessment, and remediation technologies.
- Concepts and safety in radioactive waste management.
- Role of the geological and engineered barriers and radionuclide transport in geological media.

Prerequisites / notice

Competencies

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Method-specific Competencies

| Analytical Competencies | Decision-making | Problem-solving | Project Management | Fostered |

Social Competencies

| Communication | Cooperation and Teamwork | Customer Orientation | Negotiation | Fostered |

Personal Competencies

| Adaptability and Flexibility | Creative Thinking | Critical Thinking | Integrity and Work Ethics | Fostered |
| Self-awareness and Self-reflection | Self-direction and Self-management | Fostered |

Prerequisites / notice

EM: Water Infrastructure Planning and Stormwater Management

Elective Module for Majors "Environmental Technologies", "Resource Management", "River and Hydraulic Engineering" and "Water Resources Management".

Number  Title Type ECTS Hours Lecturers
102-0250-00L Urban Drainage Planning and Modelling W 6 credits 4G M. Maurer, U. Karaus, J. P. Leitão Correia, M. Stähle

Abstract
In this course, students learn modern urban drainage engineering approaches, critical thinking, decision making in a complex environment as well as dealing with insufficient data and ill-defined problems.

Objective
By the end of the course, you should be able to do the following:
- Apply different methods and methodologies to assess the impact of urban drainage on water pollution and flooding potential.
- Distinguish between hydrological and hydrodynamic models and their correct application.
- Identify the difference between emission and immission oriented approaches for identifying drainage measures.
- Identify relevant measures, quantify their effects and assess their relative ranking/priority.
- Consider uncertainties and handle incomplete data and information.
- Make decisions and recommendations in a complex application case.
- Teamwork. State principles of effective team performance and the functions of different team roles; work effectively in problem-solving teams.
- Communication. Communicate and document your findings in concise group presentations and a written report.

Content
In urban drainage, the complexity of the decision-making, the available methodologies and the data availability have increased significantly. In current environmental engineering practice, the focus has shifted from tables and nomograms to sophisticated simulation tools. The topics cover:
- Integrated urban water management
- Hydrological and hydrodynamic modelling
- Water quality based assessment
- Freshwater ecology
- Hydraulic capacity assessment
- Sewer network operation
- Decision analysis

Prerequisites / notice
Prerequisites: 102-0214-00 Siedlungswasserwirtschaft and 102-0215-00 Siedlungswasserwirtschaft II or comparable educational background.

Competencies

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Method-specific Competencies

| Analytical Competencies | Decision-making | Media and Digital Technologies | Problem-solving | Project Management | Fostered |

Social Competencies

| Communication | Cooperation and Teamwork | Customer Orientation | Fostered |

Personal Competencies

| Adaptability and Flexibility | Creative Thinking | Critical Thinking | Fostered |
| Self-awareness and Self-reflection | Self-direction and Self-management | Fostered |

EM: Water Resources Management

Elective Module for Majors "Environmental Technologies", and "Urban Water Management".

Number  Title Type ECTS Hours Lecturers
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling. Written material will be available.

There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

The second part (B) of the course on conceptual watershed models builds their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling. Written material will be available.

There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Precourse reading
- Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences).
- Basic knowledge of Matlab (Python).

Literature
- Standard textbooks in hydrology, such as D. Braun, F. Evers, M. Flariancic, and S. Frei, P. U. Lehmann Grunder.
- Research papers collected by the instructors on the course Moodle page.

Prerequisites

1. Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences).
2. Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).
3. Some experience with GIS or data analysis is helpful.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- GIS

Method-specific Competencies
- GIS
- ArcGIS

Social Competencies
- Cooperation and Teamwork
- Communication
- Networking

Personal Competencies
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management
- Media and Digital Technologies
- Decision-making
- Integrity and Work Ethics
- Media and Digital Technologies
- Decision-making
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Specialized Computer Laboratory

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<th>Number</th>
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<td>O</td>
<td>0</td>
<td>6P</td>
<td>D. Braun, D. F. Vetsch, L. von Känel, to be announced</td>
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</table>

Abstract
In the Experimental and Computer Laboratory students are introduced to research and good scientific practice. Experiments are conducted in different disciplines of environmental engineering. Data collected during experiments are compared to the corresponding numeric simulations. The results are documented in reports or presentations.

Objective
The student will learn the following skills: basic scientific work, planning and conducting scientific experiments, uncertainty estimations of measurements, applied numerical simulations, modern sensor technology, writing reports.

Content
The Experimental and Computer Laboratory is building on courses in the corresponding modules. Material from these courses is a prerequisite or co-requisite (as specified below) for participating in the Experimental and Computer Laboratory (MODULE: Project in the Experimental and Computer Laboratory): - Wafinfra: Water Network Management
- UWM: SysUWM + ProcUWM: Operation of Lab-WWTP
- AIR: Air Quality Measurements
- WasteBio: Anaerobic Digestion
- WasteRec: Plastic Recycling
- ESD: Environmental Assessment
- GROUND: Groundwater Field Course Kappelen
- WRM: Modelling Optimal Water Allocation
- FLOW: 1D Open Channel Flow Modelling
- LAND: Landscape Planning and Environmental Systems
- RIVER: Discharge Measurements
- HydEng: Hydraulic Experiments
- RemSens: Earth Observation and Landscape Planning
- SOIL: Soil and Environmental Measurements Lab

Lecture notes
Written material will be available.

Electives

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<td>Supplementary Course to Project LAND within Experimental and Computer Lab.</td>
<td>W</td>
<td>1</td>
<td>1U</td>
<td>D. Braun</td>
</tr>
</tbody>
</table>

This is a supplementary course for students in the Laboratory Courses in Environmental Engineering who wish to complete all the exercises in Landscape planning and environmental system, as in the 3CP course 103-0347-01L Landscape Planning and Environmental Systems (GIS Exercises).

Abstract
Supplement course to Project LAND in the Experimental and Computer Lab. Methods for the identification and measurement of landscape structure, changes, functions and services, as well as measures and implementation of landscape planning are deepened.

Objective
Methods for the identification and measurement of landscape structure, changes, functions and services, as well as measures and implementation of landscape planning are deepened.
The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

Course Catalogue of ETH Zurich

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0010-01L</td>
<td>Master's Thesis</td>
<td>W</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract

The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 28 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective

To work independently and to produce a scientifically structured work.

Content

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0203-AAL</td>
<td>Hydraulics I</td>
<td>E-</td>
<td>5 credits</td>
<td>11R</td>
<td>R. Stocker</td>
</tr>
</tbody>
</table>

Abstract

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Objective

Familiarization with the basics of hydromechanics, relevant for civil and environmental engineers.

Content

Properties of water, hydrostatics, continuity, Euler equation of motion, Navier Stokes equation, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids-real fluids, boundary layer, pipe flow, open channel flow, flow in porous media, flow measurements, demonstration experiments in the lecture hall and in the laboratory.

Lecture notes

Script and collection of problems available

Literature

Bollrich, Technische Hydromechanik 1, Verlag Bauwesen, Berlin

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0214-AAL</td>
<td>Introduction to Urban Water Management</td>
<td>E-</td>
<td>6 credits</td>
<td>13R</td>
<td>E. Morgenroth, M. Maurer</td>
</tr>
</tbody>
</table>

Abstract

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Objective

Introduction to urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). Introduction to Urban Water Management is a self-study course.

Content


Lecture notes


Literature

In this self-study course the students must work through and understand selected sections from the following book


Students must understand and be able to discuss the required reading in a 30 min oral exam. The required reading is explained in detail on the website of the professorships of urban water management. Additional information can be obtained during the office hours of the professors' assistants.

The required reading and studying should correspond roughly the time invested in the course Siedlungswasserwirtschaft GZ. Students are welcome to ask the assistants (http://www.sww.ifu.ethz.ch/group/teaching-assistants.html) for help with questions they have regarding the reading.
Some students joining the MSc program in Environmental Engineering at ETH Zürich have to take additional courses from our BSc program. The decision of what courses to take is done at the time of admission at ETH.

The course on "Introduction to Urban Water Management" is offered at ETH Zürich only in German. Students who can speak and understand German must take the course (Siedlungswasserwirtschaft GZ) and get a passing grade. For students that do not have sufficient German language skills there is a self-study course and they have to take an oral exam.

This course is required for further in depth courses in urban water management.

**Prerequisite:** Hydraulics I and Hydrology

### Competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed

**Social Competencies**
- Customer Orientation: fostered

**Personal Competencies**
- Critical Thinking: assessed
- Self-direction and Self-management: fostered

---

**102-0324-AAL  Ecological Systems Analysis**

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*

**E-6 credits 13R S. Hellweg**

- Methodological basics and application of various environmental assessment tools.

**Objective**

Students learn about environmental assessment tools, such as material flow analysis, risk assessment, and life cycle assessment. They can identify and apply the appropriate tool in a given situation. Also, they are able to critically assess existing studies.

**Content**

- Methodological basics of material flow analysis, risk assessment and life cycle assessment
- Application of these methods to case studies

**Lecture notes**

No script, but literature available on moodle

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**102-0325-AAL Waste Management**

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*

**E-4 credits 9R M. Haupt**

- Introduction into the problems of waste handling with the goal to get the ability of seeing and improving the influence of commodities and products with there packaging to the environment - as they are becoming waste. Knowing the different mechanical and chemical processes, which are applicable in the field of waste management.

**Objective**

In the course "Waste Management", the competencies of process understanding, system understanding, modeling, concept development, measurement methods and data analysis & interpretation are taught. The competencies process understanding and system understanding are applied and examined in addition. Concept development is also examined.

**Content**

- This lecture gives a comprehensive overview of the different waste-types and waste handling possibilities:
  - Waste composition as a mirror of the human evolution
  - Waste definition (formation, amount, energy content, waste composition)
  - Several recycling possibilities and processes
  - Thermal waste treatment (electricity/district heat as products), including off-gas cleaning and incineration residue handling with regards to the final residue storage in a landfill and the problems which have to be solved there
  - Special fields like biological waste handling (composting, fermentation), handling of special wastes and municipal sewage sludge treatment
  - Economical aspects

**Lecture notes**

Martin F. Lemann, Christoph Leitzinger, Leo S. Morf: Waste Management Edition 2020, 433 pages
ISBN 978-3-9525297-0-6

**Literature**

Martin F. Lemann, Christoph Leitzinger, Leo S. Morf: Waste Management Edition 2020, 433 pages
ISBN 978-3-9525297-0-6

**Prerequisites / notice**

basic of chemical processes has to be known
## Competencies

### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

### Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Groundwater I

**Abstract**
The course provides a quantitative introduction to groundwater flow and contaminant transport.

**Objective**
In “Groundwater I” the competencies of process understanding are taught, applied and examined. Furthermore, system understanding and concept development are taught and applied, which are previous steps to groundwater modeling. To add measurement methods are taught and data analysis & interpretation is applied during the course.

**Content**
- Properties of porous and fractured media
- Darcy’s law, flow equation, stream functions, interpretation of pumping tests, transport processes, transport equation, analytical solutions for transport, numerical methods: finite differences method
- Aquifers remediation, case studies

**Literature**
- W. Kinzelbach, R. Rausch, Grundwassermodellierung, Gebrüder Bornträger, Stuttgart, 1995

### Air Pollution Control

**Abstract**
The lecture provides an introduction to the formation of air pollutants by technical processes, the emission of these chemicals into the atmosphere and the impact on air quality. Theoretical description and modeling of these processes, air quality measurement techniques and pollution control techniques are covered.

**Objective**
The students gain general knowledge of the factors resulting in air pollution and the techniques used for air pollution control. The students can identify major air pollution sources and understand the methods for measurement, data collection and analysis. The students can evaluate possible control methods and equipment, design a control system and estimate the efficiency and cost.

**Content**
- The physical and chemical processes leading to emission of pollutants
- Air quality analysis
- The meteorological parameters influencing air pollution dispersion
- Deterministic and stochastic models, describing the air pollution dispersion
- Measurement concepts to observe ambient air pollution
- Removal of gaseous pollutants by absorption and adsorption
- Control of NOx and SOx
- Fundamentals of particulate control
- Design and application of wet scrubbers

**Literature**
- Text book

**Prerequisites / notice**
College lectures on basic physics, chemistry and mathematics.
### Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>fostered</td>
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<tr>
<td></td>
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<td>assessed</td>
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<td></td>
<td>Project Management</td>
<td>fostered</td>
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<tr>
<td>Social Competencies</td>
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<td></td>
<td>Creative Thinking</td>
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<td>Integrity and Work Ethics</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### Introduction to Water Resources Management (102-0474-AAL)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
The course offers an introduction to the basics of water resources analysis and management covering the topics of water demand vs availability, water exploitation and reservoir design, aquatic physics, water quality and pollution, water conservation and remediation in rivers, lakes and aquifers, sustainable water use.

**Objective**
Introduction to the basics of sustainable water resources management based on relevant hydrological processes, management approaches and mathematical models.

**Content**

Example of application of modelling techniques are made available on selected topics. Four computer-based class exercises on selected topics are offered and guided through teaching assistants.

**Lecture notes**
Handouts of slides and additional reading material are provided on the Moodle course webpage (https://moodle-app2.let.ethz.ch/course/view.php?id=14738)

**Literature**
Literature information is provided either in the handouts or on the Moodle course webpage (https://moodle-app2.let.ethz.ch/course/view.php?id=14738)

**Prerequisites / notice**
Knowledge from the course “Hydrology” (3rd semester Environmental Engineering) and about basic statistics and probability theory is a prerequisite (not formal).

### Computer Science II (252-0846-AAL)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
Introduction to programming in Java. Procedural foundations of programming and outlook to object oriented programming. Working with a professional programming environment (Eclipse).

**Objective**
In the course “Computer Science II”, the competencies of programming, modeling and data analysis & interpretation are taught, applied and examined. The students will be able to write simple programs and to modify existing programs.

**Content**
This course offers an introduction to variables, control structures (branch, loop), algorithms and data structures, as well as an outlook to modularisation and object oriented techniques. The exercises students train programming skills (in the programming language JAVA), Students can solve the exercises on their own laptop or in the computer labs at ETH. The software used in this course runs on MS Windows, MacOS X and Linux.

**Prerequisites / notice**
Prerequisites: 252-0845-00 Computer Science I (D-BAUG)

### Chemistry I and II (529-2001-AAL)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract

General Chemistry I and II: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium, kinetics, acids and bases, electrochemistry

Objective

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content

1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

Lecture notes

Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

Literature

Housecroft and Constable, CHEMISTRY
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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Abstract

Chemistry II: Redox reactions, chemistry of the elements, introduction to organic chemistry

Objective

Erweitern der allgemeinen Grundlagen und Erarbeiten einer Basis, um Prozesse in komplexeren Umweltsystemen (Wasser / Luft / Boden) in ihrem zeitlichen und quantitativen Ablauf verstehen und beurteilen zu können.

Content

1. Redoxreactions
2. Inorganic Chemistry
   - Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronoc structure of the elements.
   - Introduction to organic chemistry
   - Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups. Stereochemistry.
   - Reaction mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds), Chemistry of carbony and carboxyl groups.
   - Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronoc structure of the elements.

3. Introduction to organic chemistry
   - Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups. Stereochemistry.
   - Reaction mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds), Chemistry of carbony and carboxyl groups.

Lecture notes


Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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Abstract

Biochemistry

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Objective

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Lecture notes


Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered
Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo.

Objective
Based on the biology and chemistry courses in the 1. and 2. semester more detailed biochemical knowledge about enzymology, membrane biochemistry, and central metabolism will be presented.

Content
Program
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Lipids and biological membranes
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design. Repetition of basic thermodynamics
Glycolysis
The citric acid cycle
Oxidative phosphorylation

Lecture notes
by Laurence A. Moran (Author), Robert A Horton (Author), Gray Scrimgeour (Author), Marc Perry (Author)

Literature
by Laurence A. Moran (Author), Robert A Horton (Author), Gray Scrimgeour (Author), Marc Perry (Author)

Prerequisites / notice
Basic knowledge in biology and chemistry is a precondition.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Self-study course in microbiology.

Objective
Teaching of basic knowledge in microbiology.

Content
This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology.

Literature
This self-study course is based on the book ‘Brock, Biology of Microorganisms’.

752-4001-AAL Microbiology E- 2 credits 4R M. Schuppler

Abstract
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Objective
Teaching of basic knowledge in microbiology.

Content
This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology.

Literature
This self-study course is based on the book ‘Brock, Biology of Microorganisms’.

102-0293-AAL Hydrology E- 3 credits 6R P. Burlando

Abstract
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Objective
Kenntnis der Grundzüge der Hydrologie. Kennenlernen von Methoden, zur Abschätzung hydrologischer Grössen, die zur Dimensionierung von Wasserbauwerken und für die Nutzung von Wasserressourcen relevant sind.

Content
Der hydrologische Kreislauf: globale Wasserressourcen, Wasserbilanz, räumliche und zeitliche Dimension der hydrologischen Prozesse.
Niederschlag: Niederschlagsmechanismen, Regenmessung, räumliche/zeitliche Verteilung des Regens, Niederschlagsregime, Punktniederschlag/Gebietsniederschlag, Isohyeten, Thiessenpolygon, Extremniederschlag, Dimensionierungsniederschlag.
Interzeption: Messung und Schätzung.
Evaporation und Evapotranspiration: Prozesse, Messung und Schätzung, potentielle und effektive Evapotranspiration, Energiebilanzmethode, empirische Methode.
Infiltration: Messung, Horton-Gleichung, empirische und konzeptionelle Methoden, F-index und Prozentuale Methode, SCS-CN Methode.
Schnee und Eis: Schneeereignisse und -messungen Schätzung des Schneeabflusses durch die Energiebilanzmethode, Abluft aus Schneesmelze, Temperatur-Index- und Grad-Tag-Verfahren.
Ein internes Skript ist zur Verfügung (kostenpflichtig, nur Herstellungskosten)

Die Kopie der Folien zur Vorlesung können auf den Webseiten der Professur für Hydrologie und Wasserwirtschaft herunterladen werden


Vorbereitend zu Hydrologie I sind die Vorlesungen in Statistik. Der Inhalt, der um ein Teil der Übungen zu behandeln und um ein Teil der Vorlesungen zu verstehen notwendig ist, kann zusammengefasst werden, wie hintereinander es beschrieben wird:
Elementare Datenverarbeitung: Hydrologische Messungen und Daten, Datenreduzierung (grafische Darstellungen und numerische Kenngrössen).

**Lecture notes**

**Physics**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

This course gives an overview of important concepts in classical dynamics, thermodynamics, electromagnetism, quantum physics, and special relativity. Emphasis is placed on demonstrating key phenomena using experiments, and in developing skills for quantitative problem solving.

Objective

The goal of this course is to make students able to explain and apply the basic principles and methodology of physics to problems of interest in modern science and engineering. An important component of this is learning how to solve new, complex problems by breaking them down into parts and applying approximations.

Content

Oscillations and waves in matter

Thermodynamics (temperature, heat, equations of state, laws of thermodynamics, entropy, transport)

Electromagnetism (electrostatics, magnetostatics, circuits, Maxwell's equations, electromagnetic waves, induction, electromagnetic properties of materials)

Overview of quantum and atomic physics

Introduction to special relativity

Lecture notes

Lecture notes and exercise sheets will be distributed via Moodle.

Literature


Competencies

Subject-specific Competencies

Concepts and Theories

Assessed

Techniques and Technologies

Assessed

Method-specific Competencies

Analytical Competencies

Assessed

Decision-making

Fostered

Media and Digital Technologies

Fostered

Problem-solving

Assessed

Project Management

Fostered

Social Competencies

Communication

Fostered

Cooperation and Teamwork

Fostered

Customer Orientation

Fostered

Leadership and Responsibility

Fostered

Self-presentation and Social Influence

Fostered

Sensitivity to Diversity

Fostered

Negotiation

Fostered

Personal Competencies

Adaptability and Flexibility

Fostered

Creative Thinking

Fostered

Critical Thinking

Fostered

Integrity and Work Ethics

Fostered

Self-awareness and Self-reflection

Fostered

Self-direction and Self-management

Assessed

**Stochastics (Probability and Statistics)**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective

The objective of this course is to build a solid fundamend in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2415 of 2667
Abstract
Introduction to Linear Algebra

Objective
Basic knowledge of linear algebra as a tool for solving engineering problems. Understanding of abstract mathematical formulation of technical and scientific problems.

Content
Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces.

Literature

Competencies

E- 5 credits

406-0142-AAL Analysis II

Abstract
Mathematical tools of an engineer

Objective
Mathematics as a tool to solve engineering problems, mathematical formulation of problems in science and engineering. Basic mathematical knowledge of an engineers.

Content

Literature
- J. Stewart: Multivariable Calculus, Thomson Brooks/Cole
- V. I. Smirnov: A course of higher mathematics. Vol. II. Advanced calculus
- M. Akveld, R. Sperb, Analysis II, vdf
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

Competencies

E- 7 credits

406-0243-AAL Analysis I and II

Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers.

Literature

E- 14 credits

406-0243-AAL Analysis I and II

Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers.

Literature
Content
Complex numbers.  
Calculus for functions of one variable with applications.  
Simple Mathematical models in engineering.


Literature
Textbooks in English:

Textbooks in German:
- M. Akveld, R. Sperb: Analysis I, vdf  
- M. Akveld, R. Sperb: Analysis II, vdf  
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag  
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

Environmental Engineering Master - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

Key for Hours

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |
| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Environmental Studies TC

Detailed information on the programme at: https://www.ethz.ch/en/studies/teacher-training.html

### Educational Science

Bitte beachten Sie, dass sich die Lerneinheitsnummer ab dem HS24 ändern wird. Diese Änderung hat keinen Einfluss auf die bisher absolvierten Lerneinheiten und erbrachten Leistungen und wird für den jeweiligen Studienabschluss anerkannt.

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<th>Number</th>
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<tr>
<td>871-0240-00L</td>
<td>Human Learning (EW1)</td>
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<td>2V</td>
<td>E. Stern, M. Rau</td>
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<td>learning in childhood and adolescence.</td>
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<td>This course looks into scientific theories and also empirical</td>
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<td>studies on human learning and relates them to the school.</td>
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<td>Anyone wishing to be a successful teacher must first of all understand</td>
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<td>the learning process. Against this background, theories and findings</td>
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<td>on the way humans process information and on human behaviour are</td>
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<td>prepared in such a manner that they can be used for planning and</td>
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<td>conducting lessons. Students additionally gain an understanding of</td>
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<td>what is going on in learning and behavioural research so that teachers</td>
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<td>are put in a position where they can further educate themselves in</td>
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<td>the field of research into teaching and learning.</td>
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<td>Thematicen Schwerpunkte: Lernen als Verhaltensänderung und als</td>
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<td>Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer</td>
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<td>Berücksichtigung der Verarbeitung symbolischer Information; Lernen</td>
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<td>als Wissenskonstruktion und Kompetenzerwerb unter besonderer</td>
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<td>Erklärungen; Die Rolle von Emotion und Motivation beim Lernen;</td>
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<td></td>
<td>Individuelle Unterschiede in der Lernfähigkeit und ihre Ursachen:</td>
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<td>Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<td>Lernformen: Theorien und wissenschaftliche Konstrukte werden</td>
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<td>zusammen mit ausgewählten wissenschaftlichen Untersuchungen in Form</td>
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<td>Stunde die Inhalte durch die Bearbeitung von Aufträgen in einem</td>
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<td>elektronischen Lerntagebuch. Über die Bedeutung des Gelernten für</td>
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<td>den Schulalltag soll reflektiert werden. Ausgewählte</td>
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<td>Tagebucheinträge werden zu Beginn jeder Vorlesung thematisiert.</td>
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<td>Lecture notes</td>
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<td>Literature</td>
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<td>1) Marcus Hasselhorn &amp; Andreas Gold (2006), Pädagogische Psychologie:</td>
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<td>Erfolgreiches Lernen und Lehren. Stuttgart: Kohlhammer. 2) Jeanne</td>
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<td>Hall. 3) Greutmann, Saalbach, Stern (Hrsg.), (2020):</td>
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<td>Professionelles Handlungswissen für Lehrerinnen und Lehrer. Kohlhammer</td>
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<td>Prerequisites / notice</td>
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<td>programs “Lehrplom” or “Didaktisches Zertifikat”. It is about learning</td>
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<td>871-0242-06L</td>
<td>Cognitive Activating Instructions in MINT Subjects ■ W J</td>
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<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
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<td>Enrollment only possible with matriculation in Teaching Diploma</td>
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<td>or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td>This course unit can only be enrolled after successful participation</td>
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<td>Abstract</td>
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<td>This seminar focuses on teaching units in chemistry, physics and</td>
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<td>mathematics that have been developed at the MINT Learning Center of</td>
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<td>the ETH Zurich. In the first meeting, the mission of the MINT</td>
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<td>Learning Center will be communicated. Furthermore, in groups of two,</td>
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<td>the students will intensively work on, refine and optimize a teaching</td>
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<td>unit following a goal set in advance.</td>
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<td>Objective</td>
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<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td>- Get information about recent literature on learning and instruction</td>
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<td>Prerequisites / notice</td>
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<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und</td>
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<td>persönliches Erscheinen zum ersten Lehrveranstaltungstermin</td>
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<td>871-0242-07L</td>
<td>Human Intelligence ■ W J</td>
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<td>Enrollment only possible with matriculation in Teaching Diploma or</td>
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<td>The focus will be on the book “Intelligenz: Grosse Unterschiede und</td>
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<td>ihre Folgen” by Stern and Neubauer. Participation at the first meeting</td>
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<td>is obligatory. It is required that all participants read the complete</td>
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<td>book. Furthermore, in two meetings of 90 minutes, concept papers</td>
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<td>developed in small groups (5 - 10 students) will be discussed.</td>
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<td>Objective</td>
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<td>- Understanding of research methods used in the empirical human sciences</td>
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<td>- Getting to know intelligence tests</td>
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<td>- Understanding findings relevant for education</td>
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<td>871-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W DZ) ■</td>
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<td>3S</td>
<td>S. Maurer, P. Caprez, I.</td>
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<td>The successful participation in EW1 (“Human Learning”) and EW2</td>
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<td>(&quot;Designing Learning Environments for School&quot;) is recommended, but not</td>
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<td>a mandatory prerequisite.</td>
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<td>In this class, students will learn concepts and skills for coping</td>
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<td>with psychosocial demands of teaching</td>
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<td>(1) They know relevant rules of conversation and conflict management</td>
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<td>and are able to apply them in an appropriate way in the school</td>
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<td>context (e.g. in parental talks).</td>
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<td>(2) They know core aspects of classroom management and know how to</td>
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<td>apply it concretely (e.g. promoting a positive learning atmosphere,</td>
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<td>avoiding disciplinary difficulties) and they are aware of possible</td>
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<td>contacts (e.g. illegal or psychological services).</td>
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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2418 of 2667
participation in the course 871-0240-00L "Human Learning (EW 1)".

Abstract
Course promotes exchange between student teachers and elementary school teachers in STEM teaching with 3 parts: 1) block seminar (ca. 16 h), 2) collaboration with elementary school teacher in a class (ca. 34 h, with approx. 50% spent in the elementary or middle school class and ca. 50% for preparation), and 3) final report (ca. 10 h). Registration implies participation in all 3 parts.

Objective
Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.). During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students' level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

Content
Students learn more about the potential and challenges of pupils. They get to know the early stages of knowledge as well as the development of pre-concepts of students in their subject area. The seminar with a phase of cooperation consists of three phases: In the block seminar, pre-concepts are discussed in their own subject as well as theoretical inputs from developmental and cognitive psychology. During the cooperation phase, a teaching task defined by the primary and secondary school teachers is actively undertaken in a class. Finally, a final report is written, which contains a description of the students’ level of knowledge. This seminar is only suitable for students who can adapt flexibly to the needs of pupils from lower class levels.

Prerequisites / notice
https://www.minterlink.ch/student

Competencies
Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Sensitivity to Diversity
Social Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection

Subject Didactics and Professional Training
Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>701-0822-00L</td>
<td>Mentored Assignment</td>
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<td>4A</td>
<td>C. Colberg, F. Keller</td>
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</table>

Abstract
The mentored paper is designed to bring together the findings from the 701-0823-00L Environmental Education Didactics I Information and the 701-0825-10L Environmental Education Didactics II. By using various teaching techniques and methods a semester plan, which is based on various curricula will be elaborated for a given topic.

Objective
1. The students have planned a curriculum for a semester course.
2. Students reflect on formative and summative ways such a teaching unit to examine and implement parts of it.
3. The students have implemented parts of the semester curriculum.
4. The students deal with the question to what extend teaching techniques, teaching methods but also sequences of self-study must be involved in the planning.

Content
Semester Planning
The students plan on the basis of the given curricula a teaching sequence. The resulting learning process is divided in phases with respect to a reasonable rhythm selecting different teaching methods.

Contents
Self-study
The students deal with various forms of self-study (moderated self-study, learning journal, PBL, case studies, etc.) and their integration in the semester plan. In addition to the formulation and determination of elements for self-study, they consider how they can check their effectiveness.

Tests
The students use adequate various types of examinations. They consider formative and summative ways. For this purpose they formulate test questions and tasks to match the objectives in the curriculum and semester schedule. The use of appropriate literature is required

Literature Study
The mentored assessment requires a specific study of literature which must be cited accordingly.

Lecture notes
A manual gives the students a guideline how to proceed.

Literature
The use of appropriate literature is part of the grading.

Prerequisites / notice
Completion of FD1 and FD2
Environmental Education Didactics I

Enrolment to Master’s degree studies required. Recognition either for Master’s degree studies or for Teaching Certificate.

Abstract
Environmental Education Didactics supplies the basic concepts for the application of the contents of the lecture Human Learning (EW 1) in environmental education.
On the basis of selected environmental topics didactical theories are used practice-oriented, whereas the appliance of different teaching methods is pointed out. In addition a didactical topic is exercised exemplary in an assignment.

Objective
- Application of the principles and topics of educational sciences on environmental contexts.
- Berufsfelder, Denkansätze, unsere Orientierung, Möglichkeiten der Umweltlehre, Umsetzungen des Stoffes, Wirkungen auf Zuhörer/innen, Konfliktmanagement; Anwendungen allg. Didaktik z. B. in den Bereichen: Globale Umweltzusammenhänge, Klima, Kreisläufe, Boden als Lebensgrundlage, Abfallwirtschaft, Ökobilanzierung als Beurteilungsgrundlage, Schadstoffe in der Umwelt, Quellenarbeit, Umwelt und Wirtschaft, Medien und Umfeld, Zukunftsperspektiven

Content
The students will be able to watch and evaluate the teaching of colleagues and experts. They get profit out of their teaching experiences not only when preparing but also when teaching. Doing so they will be supported by their mentors.
Two lessons of the course will be split off for the examination - procedure.

Teaching Internship Including Examination Lessons

Prerequisite: successful participation in Mentored Assignment (701-0822-00L).

Abstract
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practice finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content
The students will be able to watch and evaluate the teaching of colleagues and experts. They get profit out of their teaching experiences not only when preparing but also when teaching. Doing so they will be supported by their mentors.
Lecture notes
Dokumente unter
https://www.ethz.ch/de/studium/didaktische-ausbildung/studienangebot-zulassung/didaktik-zertifikat/dokumente--didaktik-zertifikat-.html

- Raster zum Bericht über das Unterrichtspraktikum im DZ Umweltlehre an der ETH Zürich (PDF)
- Beurteilungsbogen Prüfungslektionen Umweltlehre
- Schriftliche Unterrichtsvorbereitung für Prüfungslektionen (PDF)

Literature
Wird von der Praktikumslehrperson bestimmt.

Competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies fostered
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management fostered

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Leadership and Responsibility assessed
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity assessed
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management fostered

Environmental Studies TC - Key for Type

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<thead>
<tr>
<th>Code</th>
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<tr>
<td>O</td>
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<tr>
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<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
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Key for Hours

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<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
Tutors will compile the case study dossier on the basis of the student reports of the autumn semester.

Cooperation and Teamwork

Type: Project Management

In the first semester the students compile what is known about the case topic, its principles and challenges. Each group of students makes

H. Bugmann, N. Gruber

The lecture discusses the role of the environmental systems based on selected environmental problems, among these the exploration of

Students are able:

Slides are provided by instructors and are accessible via moodle.

Methodological documentation will be made available on Moodle during the case study together with the relevant background literature.

fostered

assessed

Aquatic ecosystems and their function, water use and its impact, water pollution and water treatment, water and health, water technologies, water & energy.

Tackling Environmental Problems I

701-0007-00L

Students are able:
- carry out research on a given topic and present the results in a structured report which (a) shows the state of knowledge and (b) the need for knowledge and action (UPL I).
- to integrate knowledge of diverse perspectives in a qualitative systems model, to identify problems and to suggest possible solutions from a specific stakeholder’s perspective (UPL II).
- name the different roles within a group. explain the role(s) they are suited for, self-organise in groups, identify problems of collaboration and constructively address the problems (UPL I and II).

In the first semester the students compile what is known about the case topic, its principles and challenges. Each group of students makes an inquiry to a given part of the overall problem. The inquiry includes a thematic as well as stakeholder analysis. The results are written in a report and presented at an internal conference.

During synthesis week, which takes place during semester break, the results of the different part inquiries are integrated in a qualitative system model. The students identify specific problems and develop solutions.

Most of the time students work independently in groups. Tutors support the students in key steps. Introductions are given for:
- The overall topic of the case study (by external experts),
- Inquiry, scientifc writing and managing references (by experts of ETH library),
- Role behaviour and collaboration in groups,
- Preparing reports, posters and presentations,
- Qualitative system modelling (SystemQ),
- Developing solutions (design thinking, Checklands' soft systems methodology, sustainability assessment).

Lecture notes

Tutors will compile the case study dossier on the basis of the student reports of the autumn semester.

Literature

Methodological documentation will be made available on Moodle during the case study together with the relevant background literature.

Subject-specific Competencies

Concepts and Theories

assessed

Method-specific Competencies

Project Management

fostered

Social Competencies

Cooperation and Teamwork

assessed

Sensitivity to Diversity

fostered

Personal Competencies

Critical Thinking

fostered

Self-awareness and Self-reflection

assessed

Self-direction and Self-management

fostered

Environmental Systems I

701-0027-00L

The lecture provides a science-based exploration of environmental aspects from three research fields: earth, climate, and health sciences.

The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic systems.

Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated.

Lecture notes

Slides are provided by instructors and are accessible via moodle.

Competencies

Subject-specific Competencies

Concepts and Theories

assessed

Method-specific Competencies

Project Management

fostered

Social Competencies

Cooperation and Teamwork

assessed

Sensitivity to Diversity

fostered

Personal Competencies

Critical Thinking

fostered

Self-awareness and Self-reflection

assessed

Self-direction and Self-management

fostered

Environmental Systems II

701-0029-00L

The lecture provides a science-based exploration of three important environmental systems: Inland waters, forest, and of food systems.

The students are able to explain important properties of the three environmental systems, to discuss critical drivers, trends and conflicts of their use, and to compare potential solutions.

Aquatic ecosystems and their function, water use and its impact, water pollution and water treatment, water and health, water technologies, water & energy.

Forests and agroforest systems, trends and drivers of land use changes, sustainable forest management.

The main functions, trends and challenges of agricultural and food systems are discussed based on the four dimensions of food security (availability, access, utilization of food and stability of the food systems).

Lecture notes

Lecture notes or other documentation are provided by instructors and accessible via moodle.

Competencies

Subject-specific Competencies

Concepts and Theories

assessed

Method-specific Competencies

Analytical Competencies

assessed

Media and Digital Technologies

fostered

Problem-solving

assessed

Social Competencies

Communication

fostered

Personal Competencies

Adaptability and Flexibility

fostered

Creative Thinking

assessed

Critical Thinking

assessed

Integrity and Work Ethics

fostered

Biology III: Essentials of Ecology

701-0243-01L

This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.

The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented.

A further aim of the lecture is that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.
Adaptability and Flexibility fostered

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling.

Chemistry I
1. Stoichiometry


Documents, lecture slides, exercises and relevant literature are available in Moodle. The documents for the next lecture will be available on Friday morning at the latest.

Literature

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Mathematics I
O 6 credits 4V+2U A. Cannas da Silva

Abstract
This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

Objective
Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both of these courses.

Content
1. Single-Variable Calculus:
- review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

2. Linear Algebra and Complex Numbers:
- systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

3. Ordinary Differential Equations:
- separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

Literature
- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

Prerequisites / notice
Prerequisites: familiarity with the basic notions from Calculus, in particular those of function and derivative.

Chemistry I
O 4 credits 2V+2U J. Cvengros, J. E. E. Buschmann, P. Funck, R. Verel

Abstract
General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course "Chemistry I", the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
- Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.

2. Atoms


4. Basics of chemical thermodynamics
- System and surroundings. Description of state and change of state of chemical systems.

5. First law of thermodynamics

6. Second law of thermodynamics
- Entropy. Change of entropy in chemical systems and universe. Reaction entropy.

7. Gibbs energy and chemical potential.

8. Chemical equilibrium

9. Acids and bases

10. Dissolution and precipitation.
- Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes
Online-Skript mit durchgerechneten Beispielen.
**Literature**


Weiterführende Literatur:

Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(englisch)

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

**Social Competencies**
- Communication: fostered
- Cooperation and Teamwork: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

**551-0001-00L General Biology I**

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<tr>
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<th>Type</th>
<th>ECTS</th>
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<td>Informatics</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>M. Dahinden, L. E. Fässler</td>
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</table>

**Abstract**

Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny. First in a series of two lectures given over two semesters for students of agricultural and food sciences, as well as of environmental sciences.

**Objective**

The understanding of some basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

**Content**

- Week 1-7 by Alex Widmer, Chapters 12-25
  12 Cell biology Mitosis
  13 Genetics Sexual life cycles and meiosis
  14 Genetics Mendelian genetics
  15 Genetics Linkage and chromosomes
  20 Genetics Evolution of genomes
  21 Evolution How evolution works
  22 Evolution Phylogenetic reconstructions
  23 Evolution Microevolution
  24 Evolution Species and speciation
  25 Evolution Macroevolution

- Week 8-14 by Oliver Martin, Chapters 26-34
  26 Diversity of Life Introduction to viruses
  27 Diversity of Life Prokaryotes
  28 Diversity of Life Origin & evolution of eukaryotes
  29 Diversity of Life Nonvascular&seedless vascular plants
  30 Diversity of Life Seed plants
  31 Diversity of Life Introduction to fungi
  32 Diversity of Life Overview of animal diversity
  33 Diversity of Life Introduction to invertebrates
  34 Diversity of Life Origin & evolution of vertebrates

**Lecture notes**

no script

**Literature**


**Prerequisites / notice**

This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

**Additional First Year Compulsory Courses**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers** |
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<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>M. Dahinden, L. E. Fässler</td>
</tr>
</tbody>
</table>

**Abstract**

Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists, tables and relational databases, introduction to programming.

**Objective**

The students learn to...
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data,
- query databases and understand and evaluate the corresponding database model,
- encode a problem into a program, test the program, and correct errors,
- implement models from the natural sciences as a simulation.

**Content**

- 1. Modeling and simulations
- 2. Data management with lists and tables
- 3. Data management with a relational database
- 4. Introduction to programming with Python 1 (variables & data types)
- 5. Introduction to programming with Python 2 (control structures & logic)
- 6. Introduction to programming with Python 3 (sequential data structures)

**Lecture notes**

All materials for the lecture are available at www.evim.ethz.ch

**Literature**


**Prerequisites / notice**

This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.
Laboratory Course: Elementary Chemical Techniques

Type
ECTS
Hours
Lecturers

**529-0030-00L** Laboratory Course: Elementary Chemical Techniques O 3 credits 4P A. de Mello, F. Jenny, N. Kobert, M. H. Schroth

**Abstract**
This practical course provides an introduction to elementary laboratory techniques. The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g., investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.

**Content**
The classification and analysis of natural and artificial compounds is a key subject of this course. It provides an introduction to elementary laboratory techniques, and the experiments cover a wide range of analytic and synthetic tasks:
- Selected samples (e.g., soil and water) will be analysed with various methods, such as titrations, spectroscopy, or ion chromatography. The chemistry of aqueous solutions (acid-base equilibria and solvation or precipitation processes) is studied.
- The synthesis of simple inorganic complexes or organic molecules is practised.
- Furthermore, the preparation and handling of environmentally relevant gaseous species like carbon dioxide or nitrogen oxides is a central subject of the Praktikum.

**Literature**
The instructions to the experiments will be published on Moodle.

**Com petencies**

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<th>Method-specific Competencies</th>
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**751-0801-00L** Fundamentals of Microscopy and Plant Biology O 1 credit 1V+2G E. B. Truernit

**Abstract**

**Objective**
- Capability of preparing biological specimen, microscopy and documentation. Understanding the correlation between plant structure and function at the level of organs, tissues and cells.
- Awareness of the link between plant anatomy, systematics, physiology, ecology, and development.

**Content**
- Special features of plant cells: Plastids, vacuole, cell wall. Anatomy of seed plants: From cells to organs. Anatomy and function of various plant tissues (epidermis, vascular tissue, wood, etc.). Anatomy and function of different plant organs (root, stem, leaf, flower, fruit, seed).
- Anatomical adaptations to different environments.

**Prerequisites / notice**
- Online in Moodle Course
- For further reading (not obligatory): Gerhard Wanner: Mikroskopisch-Botanisches Praktikum, Georg Thieme Verlag, Stuttgart.
- Groups of a maximum of 20 students.

**Com petencies**

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</tbody>
</table>
### Mathematics IV: Statistics

**Objectives**: Introducing basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with real data examples and applied using the statistical software R.

**Objective**: Capacity to learn from data; good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.e. also using the statistical software R. The lecture will be held in German.

**Content**: Einführung in die Wahrscheinlichkeitsrechnung (Grundregeln, Zufallsvariablen, diskrete und stetige Verteilungen, Ausblick auf Grenzwertsätze), Beschreibende Statistik (einschließlich grafische Methoden). Methoden der Analytischen Statistik: Schätzungen, Tests (einschließlich Binomialtest, t-Test, Vorzeichentest, F-Test, Wilcox-Test), Vertrauensintervalle, Vorhersageintervalle, Korrelation, einfache und multiple lineare Regression. Einführung in die statistische Programmierrsprache R.


**Technical Competencies**

- Concepts and Theories
- Techniques and Technologies

**Prerequisites / notice**: Die Übungen (ca. die Hälfte der Kontaktstunden; einschließlich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

**Voraussetzungen**: Mathematik I, II

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### Examination Block 2

**Number**

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<td>701-0071-00L</td>
<td>Mathematics III: Systems Analysis</td>
<td>O</td>
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<td>701-0023-00L</td>
<td>Atmosphere</td>
<td>O</td>
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</table>

**Examinations**:

- Mathematics III: Systems Analysis (4 credits)
- Mathematics IV: Statistics (4 credits)
- Atmosphere (3 credits)

**Lecturers**

- Brunner, R.
- Knutti, H.
- Wernli, M.
- Meinshausen, N.
- Fischer, E.
- Lohmann, U.

**Prerequisites**

- Mathematik I, II

---

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Problem-solving

- **Social Competencies**
  - Communication

- **Personal Competencies**
  - Self-direction and Self-management

---

### Mathematics III: Systems Analysis

**Objective**: Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e. Recognizing the core of the problem - simplification - quantitative approach - prediction.

**Abstract**: The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

**Literature**:


**Prerequisites**

- Mathematics I, II
- Mathematics II

**Technical Competencies**

- Concepts and Theories
- Techniques and Technologies

---

### Atmosphere

**Objective**: Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

**Abstract**: Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds.

**Literature**

Competencies

Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered
Self-awareness and Self-reflection fostered

701-0501-00L Pedosphere

Abstract
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.

Objective
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

Content
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.

Lecture notes
Polybook

Literature

Prerequisites / notice
Prerequisites: Basic knowledge in chemistry, biology and geology.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Personal Competencies
Critical Thinking fostered

Additional Compulsory Courses

Number Title Type ECTS Hours Lecturers
701-0033-00L Laboratory Course in Physics for Students of Environmental Sciences O 2 credits 4P M. Münich, A. Biland, A. Eggenberger, N. Gruber

Abstract
Learning with the basic principles of scientific experimentation. By performing experiments in different fields of experimental physics the students will learn the usage of measurement instruments as well as the correct analysis and the estimation of the accuracy of the measurement results.

Objective
Working in a laboratory forms an important part of modern scientific education. Using simple experimental setup the laboratory course will provide basic knowledge of:
- the setup of experiments,
- various measurement techniques,
- the use of various measurement instruments,
- the correct performance of experiments,
- the analysis of the accuracy of the measurements,
- and the interpretations of the measured quantities.

The course will also deepen the knowledge of experimental physics.

In addition to experiments selected from the physics lab for physicists, this lab course offers experiments specially developed for bachelor students in environmental sciences, which illustrate the mutual relationships between physical processes and chemical and biological phenomena.

Content
The students select 3 out of 18 offered experiments that they want to conduct. After conducting these experiments, the students document and analyze their measurements, estimate the accuracy of their results, and compare them with the values expected according to the laws of physics. Introductory lectures with exercises in Jupyter Notebooks as evaluation tools and in determining the accuracy of measurement results ("error calculation"), as well as a preliminary experiment for practicing experiment evaluation, complement the practical.

Lecture notes
Manuals for the experiments and Jupyter Notebook templates are provided online on the Moodle course pages.

Competencies

Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered
Media and Digital Technologies fostered
Problem-solving fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-direction and Self-management fostered

Social Sciences and Humanities

Compulsory

Number Title Type ECTS Hours Lecturers
This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, economics

Students acquire basic knowledge and methods for analyzing arguments. They are able to apply these methods to complex arguments concerning scientific and ethical questions about the environment and sustainable development, and to construct themselves arguments and apply them successfully. Moreover, they are able to evaluate the contribution of arguments to controversial debates with the help of rules. Students acquire thereby a crucial skill for Critical Thinking, which aims at responsible argumentation, communication and action.

In the sciences as well as in public discussions or in our everyday life, we try to convince others or to achieve consent in matters of disagreement. We do this with the help of arguments. But what are the criteria for arguments to be convincing and for claims to be clear? And how do we expediently feed arguments into a debate? How can we identify and avoid fallacies in reasoning? How do we analyse and define concepts? This course provides basic knowledge of conceptual analysis and argumentation theory as well as methods for identifying, reconstructing and evaluating claims and arguments. Its focus is on systematically addressing the following two questions: What do you mean? How do you know? The first question aims at a better understanding of the claim in question, the second at assessing the reasons that support or undermine the claim. We exercise and improve the abilities to address these questions by using texts on scientific and ethical questions concerning the environment and sustainable development. The course provides thus crucial skills for Critical Thinking, which aims at responsible argumentation, communication and action.

This is a compulsory course in the social sciences and humanities in the second year of the BA Environmental sciences. For 2 ECTS-credits, all written tasks that are distributed during the course need to be solved.

This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are addressed from a political science perspective both theoretically as well as by means of current Swiss environmental policy examples.

Beyond acquiring basic knowledge about public policy analysis, this course teaches students how to analytically address current and concrete questions of environmental policy. Through exercises the students learn about political science concepts and frameworks as well as real-life political decision-making processes. The well-grounded examination of complex political conflict situations is an important precondition for the entry into the (environmental policy) workforce or a future research career.

The processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

This is a compulsory course in the social sciences and humanities in the second year of the BA Environmental sciences. For 2 ECTS-credits, all written tasks that are distributed during the course need to be solved.

This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

The detailed semester program (syllabus) is made available to the students at the beginning of the semester. During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture.

This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

After successful completion of the course you will be able to:

- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general.

Environmental Law

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0703-00L</td>
<td>Environmental Ethics (University of Zurich)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>University lecturers</td>
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<tr>
<td></td>
<td>(No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.) UZH Module Code: 07SMEEE266 Please register at: <a href="https://www.uzh.ch/cmsssl/de/studies/application/chmobiliteein.html">https://www.uzh.ch/cmsssl/de/studies/application/chmobiliteein.html</a> after you received your logon information you can enrol to courses at: <a href="https://studentservices.uzh.ch/uzh/application#/Logon">https://studentservices.uzh.ch/uzh/application#/Logon</a> Mind the enrolment deadlines at UZH: <a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html">https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html</a></td>
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**Objective**

The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

- Situate contemporary political events within global power relations, and political histories of colonialism, imperialism, and gendered violence.
- Cultivate critical, decolonial, and feminist approaches to research, policy, and practice. By critical, we encourage students to question how ‘problems’ are framed rather than start with a ‘problem-solving’ mindset.
- Distinguish scientific, peer-reviewed and research-based knowledge from popular media and disinformation.
- Learn methodological skills necessary for academic research, encompassing considerations of ethics and power relations in the research process.
- Writing skills: write thoroughly researched and concise texts that analyze a case study using geographical concepts and adequate references to the scientific literature.
- Creative communication and Speaking Skills: Use the classroom as a safe space for dialogue and testing ideas respectfully, and apply artistic/creative forms for communicating research (blogs, essays, podcasts, photography, film etc.)

**Social Sciences**

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<tbody>
<tr>
<td>701-0709-00L</td>
<td>Political Geography (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>University lecturers</td>
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<tr>
<td></td>
<td>(No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH. UZH Module Code: 07SMGEO423 Mind the enrolment deadlines at UZH: <a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html">https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html</a>)</td>
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**Objective**

- Become familiar with key thinkers, concepts, theories, and illustrative case studies in political geography and apply key geography concepts to a particular case.
- Situate contemporary political events within global power relations, and political histories of colonialism, imperialism, and gendered violence.
- Cultivate critical, decolonial, and feminist approaches to research, policy, and practice. By critical, we encourage students to question how ‘problems’ are framed rather than start with a ‘problem-solving’ mindset.
- Distinguish scientific, peer-reviewed and research-based knowledge from popular media and disinformation.
- Learn methodological skills necessary for academic research, encompassing considerations of ethics and power relations in the research process.
- Writing skills: write thoroughly researched and concise texts that analyze a case study using geographical concepts and adequate references to the scientific literature.
- Creative communication and Speaking Skills: Use the classroom as a safe space for dialogue and testing ideas respectfully, and apply artistic/creative forms for communicating research (blogs, essays, podcasts, photography, film etc.)

Psychology

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<tbody>
<tr>
<td>701-0721-00L</td>
<td>Psychology</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Hansmann, A. Bearth, M. Siegrist</td>
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<td>(This course provides an introduction to psychological research and modelling, focusing on cognitive psychology and the psychological experiment. Participants learn to formulate problems for psychological investigation and apply basic forms of psychological experiment.)</td>
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Objective
Students are able to
- describe the areas, concepts, theories, methods and findings of psychology.
- differentiate scientific psychology from "everyday" psychology.
- structure the conclusions and significance of an experiment, according to a theory of psychology.
- formulate a problem for psychological investigation.
- apply basic forms of psychological experiment.

Content
Einführung in die psychologische Forschung und Modellbildung unter besonderer Berücksichtigung der kognitiven Psychologie und des psychologischen Experiments. Themen sind u.a.: Wahrnehmung; Lernen und Entwicklung; Denken und Problemlösen; Kognitive Sozialpsychologie; Risiko und Entscheidung.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-presentation and Self-reflection assessed
Self-direction and Self-management assessed

Abstract
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

Objective
Students will be able to,
- explain the decision-making processes underlying the purchasing process
- describe the factors that have an influence on consumer behavior
- develop strategies to influence purchasing behavior

Competencies

Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed

Social Competencies
Cooperation and Teamwork fostered
Customer Orientation assessed
Sensitivity to Diversity assessed

Personal Competencies
Critical Thinking assessed

Abstract
This course deals with basic questions, concepts, theories, methods, and empirical findings of political science.

Objective
This course deals with basic questions, concepts, theories, methods, and empirical findings of political science.
This course analyzes the foundations and challenges of Swiss foreign policy. After reviewing the history of foreign policy conceptions since the early 20th century, we will discuss the determining factors of Swiss foreign policy and examine, together with guest speakers from the foreign ministry, current international developments and respective foreign policy challenges.

### Lecture notes

- **Concepts and Theories**
  - Analytical Competencies
  - Problem-solving

- **Social Competencies**
  - Communication
  - Cooperation and Teamwork
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation

- **Personal Competencies**
  - Creative Thinking
  - Critical Thinking

### Prerequisites / notice

- **Subject-specific Competencies**
  - assessed
- **Method-specific Competencies**
  - assessed

### Compilations

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credit Hours</th>
<th>Title</th>
<th>Prerequisites</th>
</tr>
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<tbody>
<tr>
<td>853-0038-00L</td>
<td>3 credits</td>
<td>Swiss Foreign Policy</td>
<td>W</td>
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**Abstract**

This course analyzes the foundations and challenges of Swiss foreign policy. After reviewing the history of foreign policy conceptions since the early 20th century, we will discuss the determining factors of Swiss foreign policy and examine, together with guest speakers from the foreign ministry, current international developments and respective foreign policy challenges.

**Objective Content**

- Students should acquire a sound understanding of Swiss foreign policy and the relevant academic and political debates associated with it.
- Students will receive a handout of slides accompanying the lectures.

**Lecture notes**

- Students need to read the first chapter of the textbook "An Introduction to Political Science" by Bernauer, Jahn, Kritzinger, Kuhn, Walter (5th edition, 2022). The course is based on this textbook, with additional readings and guest speakers from the Swiss foreign ministry.

**Literature**

- The course uses guest lectures from the Swiss foreign ministry, current international developments and respective foreign policy challenges.

**Prerequisites / notice**

- Students should have a basic understanding of political science and international relations.
- The course will be supported by an e-learning environment.

**Method-specific Competencies**

- Problem-solving
- Critical Thinking

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Creative Thinking
- Critical Thinking
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

Objective
The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

Content
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

Credits and Exam
After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. Students who did not participate in the test on 18 December 2023 will not have access to the repeat test unless they submit compelling and documented (e.g. medical, other exam in parallel at ETH) reasons for why they were unable to participate in the first test. It covers all contents of the lectures and the reading assignments. Visiting students (e.g., from the University of Zurich or other universities) are subject to the same conditions. Registration for the course in the mystudies system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.

After passing the exam, students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. Students who did not participate in the test on 18 December 2023 will not have access to the repeat test unless they submit compelling and documented (e.g. medical, other exam in parallel at ETH) reasons for why they were unable to participate in the first test. It covers all contents of the lectures and the reading assignments. Visiting students (e.g., from the University of Zurich or other universities) are subject to the same conditions. Registration for the course in the mystudies system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

This course is intended to demonstrate how environmental decisions can be optimized and conflicts better dealt by using mediation. Case studies will focus on construction of windmills for electricity purpose, landfills, sustainable city-planning or Human-Wildlife Conflict and Coexistence.

A reader will be handed out.

Students can do conflict analyses, for instance, as part of individual and group analyses and a half-day mediation-simulation, develop concepts for doing and evaluating mediation processes. Students will focus on construction of windmills for electricity purpose, landfills, sustainable city-planning or Human-Wildlife Conflict and Coexistence. This course is intended to demonstrate how environmental decisions can be optimized and conflicts better dealt by using mediation. Case studies will focus on construction of windmills for electricity purpose, landfills, sustainable city-planning or Human-Wildlife Conflict and Coexistence.

Students will focus on construction of windmills for electricity purpose, landfills, sustainable city-planning or Human-Wildlife Conflict and Coexistence. This course is intended to demonstrate how environmental decisions can be optimized and conflicts better dealt by using mediation. Case studies will focus on construction of windmills for electricity purpose, landfills, sustainable city-planning or Human-Wildlife Conflict and Coexistence.
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
(1) broaden understanding of management principles and frameworks
(2) advance insights into the sources of corporate and entrepreneurial success
(3) develop skills to apply this knowledge to real-life managerial problems

Content
The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

The exercise consists of delivering and submitting a "pitch" with a clear recommendation for one of the selected cases amongst those seen in Discovering Management, using your insights from Discovering Management, and an extra session on pitching.

Students have the option to either do this alone or in a group of two students.

363-0387-00L corporate sustainability

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management (Exercises)". Does not take place this semester.

Complementary exercises for the module Discovering Management.

Prerequisite: Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.

Objective
The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Content
The exercise consists of delivering and submitting a "pitch" with a clear recommendation for one of the selected cases amongst those seen in Discovering Management, using your insights from Discovering Management, and an extra session on pitching.

Students have the option to either do this alone or in a group of two students.
Objective
Students shall obtain the following competencies:
- assess the limits and the potential of corporate sustainability for sustainable development
- develop competencies that are useful in the context of corporate sustainability and beyond (analytical competency, critical thinking, problem solving)
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams

Content
Corporate Sustainability is the flagship course of the Group for Sustainability and Technology at D- MTEC. In this course, students learn about key concepts in corporate sustainability and develop skills to implement them in the real world. The course prepares students for making well-informed sustainability decisions in their future careers.

The course uses constructive alignment to bring the various innovative teaching and learning elements (e.g., case-based experiential learning, reflective thinking and blended learning with videos and quizzes) into a coherent transformational journey. Students can now flexibly, efficiently, and effectively acquire the conceptual foundations that are essential for a substantial understanding of corporate sustainability.

For part of the course, students work in groups to complete a set of graded assignments designed to guide them into a deep dive on a selected corporate sustainability challenge. Please note that full participation in this part is essential, so make sure you are available. Furthermore, these group assignments count towards the overall grade for the course.

For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Lecture notes
Presentation slides will be made available on Moodle after lectures.

Literature
Literature recommendations will be distributed via Moodle, and are available from the start of the course.

Prerequisites / notice
TEACHING FORMAT/ ATTENDANCE: The course includes several mandatory sessions that participants must attend to successfully earn credit points. It is not possible to take the class purely online.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: fostered
- Problem-solving: assessed

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered

Personal Competencies
- Creative Thinking: fostered
- Critical Thinking: assessed
- Self-awareness and Self-reflection: fostered

851-0735-10L Startups and Law

W 2 credits 2V P. Peyrot

8 credits

Abstract
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective
The students shall obtain the following competence:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes
A comprehensive script will be made available online on Moodle platform.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed

Social Competencies
- Communication: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
### 363-0537-00L Resource and Environmental Economics

**Abstract**
Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

**Objective**
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

**Content**
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

**Literature**

**Competencies**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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<tr>
<td>Analytical Competencies</td>
<td>Media and Digital Technologies</td>
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<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Project Management</td>
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<td>Problem-solving</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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</tbody>
</table>

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Prerequisites**
851-0626-01L International Development Cooperation
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

**Lecture notes**
A comprehensive script will be made available online on the moodle platform.

---

### 851-0735-10L Startups and Law

**Abstract**
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

**Objective**
The students shall obtain the following competence:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be able to critically discuss the various aid instruments of bi-and multilateral donors and NGOs.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

**Literature**

**Prerequisites**
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0530-00 "Principles of Microeconomics" for Master students.
**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
  - assessed

**Method-specific Competencies**

- Analytical Competencies
  - assessed
- Decision-making
  - fostered
- Problem-solving
  - assessed

**Social Competencies**

- Communication
  - fostered
- Negotiation
  - fostered

**Personal Competencies**

- Adaptability and Flexibility
  - fostered
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - fostered

**Highly recommended Natural Science and Technical Electives**

**For the Specialization in Atmosphere and Climate**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0479-00L</td>
<td>Environmental Fluid Dynamics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>H. Wernli, L. Papritz</td>
</tr>
</tbody>
</table>

**Abstract**

This course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.

**Objective**

Students are able

- to name the basics, concepts and methods of environmental fluid dynamics.
- to understand and discuss the components of the basic physical equations
- to mathematically solve basic equations for simple problems of environmental fluid dynamics.

The competencies of process understanding and system understanding are taught, applied and examined.

**Content**

Basic physical terminology and mathematical laws:
- Continuum hypothesis, forces, constitutive laws, state equations and basic principles of thermodynamics, kinematics, laws of mass and momentum on rotating earth.
- Concepts and illustrative flow systems: vorticity dynamics, boundary layers, instability, turbulence - with respect to environmental fluid systems.
- Scale analysis: dimensionless variables and dynamical similarity, simplification of the fluid system, e.g. shallow water assumption, geostrophic flow.
- Waves in environmental fluid systems.

**Competencies**

**For the Specialization in Biogeochemistry**

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>701-0225-00L</td>
<td>Organic Chemistry</td>
<td>W</td>
<td>2</td>
<td>2V+1U</td>
<td>K. McNeill</td>
</tr>
</tbody>
</table>

**Abstract**

Basics of Organic Chemistry.

Reaction mechanisms in organic chemistry: substitutions, additions, eliminations, condensations, rearrangements, electrophilic aromatic substitution

**Objective**

Students will be able to:

- Recall basic organic chemistry reactions, including substitution, elimination and addition reactions occurring at sp2- and sp3-hybridized carbon centers.
- Explain the relative favorability of certain organic chemical structures or certain organic chemical reactions.
- Apply their understanding of reaction mechanism principles to explain observations.
- Differentiate the most reactive sites in a given organic chemical.
- Propose reaction mechanisms to new chemical transformations.

**Content**

Descriptive chemistry of functional groups (alkyl halides, aikenes, aromatic systems, carbonyls).

Reaction mechanisms (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution).

**Literature**

Carsten Schmuck, Basisbuch Organische Chemie, Pearson

Der Stoff der Basischemie wird vorausgesetzt.

**Competencies**

**752-0100-00L Biochemistry**

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>752-0100-00L</td>
<td>Biochemistry</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>C. Frei</td>
</tr>
</tbody>
</table>

**Abstract**

Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo.

Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

**Objective**

Students are able to describe the structure of proteins/enzymes and are able to explain biochemical functions depending on their 3D structures.

Connections between several metabolic pathways are known and students can evaluate how one pathway is influence by the activity of another pathway
Content
Program
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design. Repetition of basic thermodynamics
Glycolysis, fermentation
The citric acid cycle
Oxidative phosphorylation and ATP physiology

Lecture notes
Horton et al. (Pearson) serves as lecture notes.

Prerequisites / notice
Basic knowledge in biology and chemistry is a prerequisite.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection

For the Specialization in Human-Environment Systems

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
</tbody>
</table>

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection

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</thead>
<tbody>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
</tr>
</tbody>
</table>

Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.
For the Specialization in Environmental Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
</tbody>
</table>

Abstract
Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3d animation database/software to use ‘anatomical language’ to retrieve anatomical structures to understand basic medical terminology

Objective
To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

Content
- The Human Body: nomenclature, orientations, tissues
- Musculoskeletal system, Muscle contraction
- Blood vessels, Heart, Circulation
- Blood, Immune system
- Respiratory system
- Acid-Base-Homeostasis

Lecture notes
Lecture notes and handouts

Literature
Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008
Faller A., Schuenke M. The Human Body; Thieme 2004
Netter F. Atlas of human anatomy; Elsevier 2014

For the Specialization in Forest and Landscape

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0266-00L</td>
<td>Introduction to Dendrology</td>
<td>W</td>
<td>3 credits</td>
<td>3P</td>
<td>A. Rudow</td>
</tr>
</tbody>
</table>

Abstract
Woody plants are important elements of forest ecosystems and landscapes. The course gives an introduction to dendrology as well as to the identification of native tree and shrub species. It is a highly recommended course for the BSc specialization of Forest and Landscape and it provides the basic requirements for the consecutive course Woody Plants of Central Europe in the spring semester.

Objective
Knowledge of selected native tree and shrub species. Understanding of biological and ecological relations by means of in situ observation of woody plants. Differentiated view on forest ecosystems.

Content
Introduction to dendrology on the basis of concrete examples. Emphasis on identification of tree and shrub species (80 frequent tree and shrub species) and on the understanding of tree structure (morphology of woody plants). The illustrating way of presentation and the relations between different scale levels (organ, individual, stand, ecosystem) provide an attractive insight into forest and landscape topics as well as into environmental biology.

Lecture notes
Rudow, A., 2023: Dendrologie 1 - Folien (in German).
Rudow, A., 2011: eBot Dendrologie (Betaversion). E-learning-Tool for the support of dendrology courses at ETHZ (application integrated in eBot, in German).

Prerequisites / notice
Half of the course will be held in form of excursions and practical training in the forest (ETH Hönggerberg). Besides that 4 half day excursions (Zurich and surroundings, on weekends, dates by arrangement). Weatherproof clothes are presupposed.

The course provides the basic knowledge for the advanced course 701-0316-00L Woody plants of Central Europe (Dendrology 2)
<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>fostered</th>
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<tbody>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<td>Self-direction and Self-management</td>
<td>fostered</td>
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</table>

### 701-0951-00L GIST - Introduction into Geoinformation Science and Technology

**Abstract**

Theoretical basics and fundamental concepts of Geographic Information Science are imparted and subsequently further elaborated with the software ArcGIS.

**Objective**

Students are able to
- elucidate the theoretical and conceptional foundations of geographic information systems (GIS)
- independently perform normal GIS work using commercial software and practical examples

**Content**

The course covers the following topics:
- What is GIS? What are spatial data?
- The representation of reality by means of spatial data models: vector, raster, TIN
- The four phases of data modelling: Spatial, conceptual, logical and physical model
- Possibilities of data collection
- Transition of reference frame
- Spatial Analysis I: query and manipulation of vector data
- Spatial Analysis II: operators and functions with raster data
- Digital elevation models and derived products
- Process modelling with vector and raster data
- Presentation possibilities of spatial data

One Friday is reserved for a field trip or guest speaker;

**Literature**


### Natural Science and Technical Electives

#### Agroecology

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</table>

**Abstract**

Die Grundlagen des Weltmärkungssystem werden anhand von Fallbeispielen aus der Forschung entlang der Wertschöpfungskette vermittelt.

**Objective**

Mit Besuch dieser Lehrveranstaltung soll Verständnis geschaffen werden, was ein Weltmärkungssystem ist, wo aktuell die grossen Herausforderungen liegen, was Elemente und Einflussfaktoren auf die Empörungssicherheit sind, welche Wechselwirkungen zwischen diesen Elementen und Einflussfaktoren bestehen, und welche potentiellen Lösungsstrategien sich für spezifische Herausforderungen ergeben lassen.

**Content**


**Lecture notes**

Skripte und zusätzliches Lernmaterial werden auf Moodle verfügbar gemacht.

**Literature**

Information zu Büchern und anderer Literatur wird während der Lehrveranstaltung bekanntgegeben.

**Prerequisites / notice**


Introduction to Agricultural Management

W 2 credits 2V R. Finger

Abstract
Vermittlung von betriebswirtschaftlichen Grundlagenwissen und Analyse- und Planungsinstrumenten mit Anwendung auf Unternehmen der Agrar- und Ernährungswirtschaft

Objective
Teilnehmer des Kurses sollen am Ende der Vorlesung i) grundlegende Unternehmensentscheide strukturieren und analysieren können, ii) verschiedene Analyse- und Planungsinstrumente auf Fragestellungen der Produktionsplanung, Investition und Finanzierung an Beispielen anwenden zu können, iii) verschiedene Werkzeuge zur unternehmerischen Entscheidungsunterstützung anwenden können und iv) die Spezifika von Unternehmen in der Agrar- und Ernährungswirtschaft kennen.

Content
Die Vorlesung geht auf folgende Inhalte, mit spezifischen Anwendungen im Agrar- und Ernährungssektors ein:

Grundlagen und Ziele unternehmerischen Entscheidens
Kosten und Leistungsrechnung
Produktionstheorie
Produktionsprogrammplanung
Investitionsplanung und Finanzierung
Entscheidungen unter Unsicherheit und Risikomanagement

Literature

Plant Nutrition I

W 2 credits 2V E. Frossard

Abstract
The aim of these lectures is to present the processes controlling the uptake and transport of nutrients by the plant, the assimilation of nutrients in the plant, the effect of nutrients on crop yield and quality, the role of the soil as a source of nutrients for crops, and the basic principles of fertilization of different crop types using mineral and organic fertilizers.

Objective
At the end of the lecture, students know how mineral nutrients are taken up through roots and circulate in the plants and what their roles in plants are. They understand the importance of nutrients for yield formation and for crop product quality. They are able to propose fertilization plans adapted for field crops growing under Swiss conditions.

Content
A general introduction explains the needs of appropriately managing nutrients in plant production. Afterwards, we will study the physiology of plant nutrition (nutrient uptake by roots; nutrient transports in the plant; physiological roles of nutrients in the plant). Then the role of nutrients for yield formation and their effects on crop quality is dealt with. Finally, the bases of crop fertilization are taught (availability of nutrient in soil; N, P and K fertilization; different types of fertilizers).

Lecture notes
The slides will be distributed

Literature

Plant Ecophysiology

W 2 credits 2V N. Buchmann, A. Walter

Abstract

Objective

Content

Lecture notes

Literature

Schubert S 2011 Pflanzenennährung Grundwissen Bachelor Ulmer UTB

Richner W. & Sinaj S., 2017. Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD 2017). Agrarforschung Schweiz 8 (6), Spezialpublikation,
Abstract

The general theme of this course is the effect of environmental factors (such as light, temperature, relative humidity, CO2 concentrations, etc.) on plant physiology: water uptake and transport, transpiration, CO2 gas exchange of plants (photosynthesis, respiration), growth and C allocation, yield and production, stress physiology. Working with measurement data and Jupyter Notebooks is included.

Objective

The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology that is necessary to analyze yield potentials in agriculture. The students will learn about classical and latest studies in plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

Content


Lecture notes

Handouts stehen online.

Literature


Prerequisites / notice

This course is based on basics of plant identification and plant physiology. It is the basis for the courses Plant Production, Part Forage Production and Grassland Systems.

Competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Analytical Competencies assessed
- Media and Digital Technologies assessed
- Problem-solving assessed

Method-specific Competencies

- Critical Thinking assessed

Personal Competencies

- Communication
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

751-5003-00L Sustainable Agroecosystems II

W 2 credits 2V K. Benabberrazik, J. Six

Abstract

This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

Objective

(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective of a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content

The course will address a wide range of agricultural and food system challenges (e.g. food security, climate crisis, soil degradation, etc.) in both temperate and tropical contexts. In class we will address topics like building food system resilience through innovative measures, improving soil fertility management or understanding the effects of agroforestry systems.

Case studies from the on-going research in the Sustainable Agroecosystems Group (sae.ethz.ch) will be presented, covering different scales (e.g. food value-chains, farm dynamics and soil management).

Students will gain an overview on institutions and actors' roles in the field of sustainable agricultural development. Throughout the group work, students will learn to engage directly with various stakeholders, monitor agroecological transition and communicate their research to a wider audience. Ultimately, this class should provide an overview on methods, tools, innovations and platforms that support a sustainable food transformation.

Literature


Prerequisites / notice

Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.

Competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Analytical Competencies assessed
- Decision-making fostered
- Problem-solving assessed
- Project Management fostered

Method-specific Competencies

- Communication fostered
- Cooperation and Teamwork assessed
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered

Social Competencies

- Adaptable and Flexible fostered
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management fostered

751-5005-00L Agroecology

W 2 credits 2G N. Buchmann, S. Keller, M. Sonneveld

Abstract

Agroecology is a discipline, an agricultural practice, and a political-social movement. Students will attend public lectures by experts from different fields and will reflect on agroecology and its principles. Moreover, students will expand their knowledge with case studies and discuss about the role of agroecology to support sustainable agriculture and food systems.
Students know the thirteen principles of the High-Level Panel of Experts (HLPE) of the Committee on World Food Security as well as the ten elements of agroecology suggested by FAO and can critically reflect on the important properties as well as benefits and trade-offs of agroecological systems and approaches.

Students will be able to transfer their disciplinary and interdisciplinary knowledge about the thirteen principles as guiding principles for policymakers, practitioners, and other stakeholders across the food system in planning, managing, and evaluating agroecological transformation. Students are part of small groups focusing on selected principles of the HLPE. During the course, students discuss the potential and limitations of agroecology and learn about scientific contributions to agroecology. Students form an opinion on the role of agroecology, reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

The course is designed as a combination of public lectures/webinars on "Agroecology and the Transformation to Sustainable Food Systems" delivered by national and international experts and scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a group work format. The public lectures bring different perspectives to the discussion and are intended as inputs for the students’ sessions. In the student sessions, the student groups deepen their knowledge of the 13 principles of agroecology proposed by the High-Level Panel of Experts (HLPE) of the Committee on World Food Security. They identify "unknows" and link to other closely related principles. The groups also work out the perspective of a chosen stakeholder. Finally, the groups will take part in a scientific discussion representing their stakeholder perspective. All groups will synthesize their discussions in a short report.

Handouts will be available on the webpage of the course. Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien".

- Vaccines, immune-therapeutic interventions
- Hypersensitivities
- Allergies
- Th1 and Th2 cells, regulatory T cells
- Cytotoxic T cells and NK cells
- Autoimmunity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Innate and adaptive immunity, Cells and organs of the immune system
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Students will be able to transfer their discipline-specific knowledge about plant ecophysiology, soil science, biogeochemistry, crop and forage science, and ecology in general. The course will be taught in English. The course is only offered in fall.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Wyss</td>
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<tr>
<td>551-0317-00L</td>
<td>Immunology</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
</tbody>
</table>

| Abstract         | Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3d animation database/software to retrieve anatomical structures to understand basic medical terminology. |
| Objective        | To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research. |
| Content          | - The Human Body: nomenclature, orientations, tissues - Musculoskeletal system, Muscle contraction - Blood vessels, Heart, Circulation - Blood, Immune system - Respiratory system - Acid-Base-Homeostasis |
| Lecture notes    | Lecture notes and handouts |

| Abstract         | Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response. |
| Objective        | Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response. |
| Content          | - Introduction and historical background - Innate and adaptive immunity, Cells and organs of the immune system - B cells and antibodies - Generation of diversity - Antigen presentation and Major Histoincompatibility (MHC) antigens - Thymus and T cell selection - Autoimmunity - Cytotoxic T cells and NK cells - Th1 and Th2 cells, regulatory T cells - Allergies - Hypersensitivities - Vaccines, immune-therapeutic interventions |
| Lecture notes    | Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien" |
| Literature       | - Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020 |
| Prerequisites / notice | For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session. |
752-6001-00L Introduction to Nutritional Science

Objective
To introduce the students to the both macro- and micronutrients in relation to food and metabolism.

Abstract
This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fats, carbohydrates, lipids, and energy metabolism. Special aspects of homeostasis and homeorhesis are emphasized.

Content
The course is divided into two parts: Micronutrients and macronutrients. The micronutrient part includes fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. The macronutrient part introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism. The nutrients are described in relation to digestion, absorption, metabolism and excretion with some focus on energy metabolism.

Lecture notes
There is no script. Powerpoint presentations will be made available.

Literature
Elmadfa I & Leitzmann C: Ernährung des Menschen
UTB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004

Garrow JS and James WPT: Human Nutrition and Dietetics
Churchill Livingstone, Edinburgh, 11th rev. ed. 2005

Soil Sciences

<table>
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<th>Hours</th>
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<tr>
<td>701-0533-00L</td>
<td>Soil and Water Chemistry</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. Kretzschmar, D. I. Christl, L. Winkel</td>
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</table>

701-0535-00L Environmental Soil Physics/Vadose Zone Hydrology

Objective
Students are able to:
- Characterize the different soils based on their key textural and structural properties.
- Simulate and predict soil water retention and flow under varying environmental conditions and understand the key driving forces (capillarity, gravity, friction) and related water properties (surface tension and viscosity).
- Predict soil hydraulic properties for varying soil textural classes.
- Predict solute transport in soils for varying environmental conditions.
- Predict energy balance and temperature dynamics in soils.
- Predict conditions for plant water stress
- Estimate the impact of soil properties on the hydrological cycle and on plant growth.

Abstract
The course provides theoretical and practical foundations for understanding and characterizing physical soil properties and processes and their relevance for terrestrial ecosystems, plant growth, hydrological processes and atmospheric-land gas exchange, across all relevant scales.

Content
Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.

Lecture notes
Lecture slides on Moodle

Literature
– Chapters 1, 3, 4, 6, 7 and 11 in Sigg/Stumm – Aquatische Chemie, 6. Auflage, vdf, 2016

Prerequisites / notice
The lecture courses Pedosphere and Hydrosphere are highly recommended.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered

Personal Competencies
Cooperation and Teamwork fostered
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Self-direction and Self-management fostered

Competencies
Subject-specific Competencies
Concepts and Theories fostered
INTRODUCTION
Week 1 (September 18)
Presentation of the role of soil physics in environmental sciences and terrestrial ecosystems: soils in the water cycle; soils and vegetation; soils and solute transport. Survey on students’ interests and expectations. Presentation of course structure and learning objectives.

BASIC SOIL PROPERTIES
Week 2 (September 25) and Week 3 (October 02)
soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density
Pore scale consideration (water in a single pore), pore sizes and shapes; surface tension; Young-Laplace equation; capillary rise; contact angle
Friction and laminar flow; Hagen-Poiseuille’s law; Washburn equation; numerical lab (REPORT 1)

SOIL HYDRAULIC PROPERTIES
Week 4 (October 09) and Week 5 (October 16)
Soil water content and soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point
Soil water characteristics and pore size distribution
Saturated water flow in soils - Laminar flow in tubes (Poiseuille’s Law); Darcy’s Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts; effective conductivity; unsaturated hydraulic conductivity; Buckingham law
Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications

TOOLBOX – MEASUREMENTS AND MODELING
Week 6 (October 23) and Week 7 (October 30)
Measuring soil hydraulic properties, fitting and interpretation; Lab tour - demonstration of soil physical methods; lecture on HYPROP method; report on Hyprop data (REPORT 2)
Modelling unsaturated water flow based on Richards equation - Using Hydrus1D for simulation of unsaturated flow; simulating HYPROP measurements (REPORT 3)

SOIL IN THE WATER CYCLE
Week 8 (November 06) – Week 9 (November 13)
Water infiltration - steady state solutions for infiltration; approximate solutions to infiltration (Green-Ampt, Philip); infiltration rate and ponding; outlook to preferential flow
Water evaporation - Energy balance and land atmosphere interactions - potential and actual evaporation, evaporation stages;

SOIL PLANT INTERACTIONS
Week 10 (November 20) Week 11 (November 27)
Root water uptake and transpiration – Theory and mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance.
Modelling root water uptake and transpiration; analytical approaches and modeling using Hydrus (REPORT 4)

SOLUTE TRANSPORT
Week 12 (December 04) Week 13 (December 11)
Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application
Transport of reactive substances, preferential flow, simulations with Hydrus

CLOSURE
Week 14 (December 18)
Summary, course synthesis, connections between the different topics, questions, exam preparation

Literature
Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Leadership and Responsibility fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

651-0032-00L Geology and Petrography W 4 credits 2V+1U K. Rauchenstein, M. O. Saar
Abstract
This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. The course consists of weekly lectures and bi-weekly exercises in groups.

Objective
This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts.

Content

Lecture notes
Weekly handouts of PPT slides via MyStudies

Literature
The course is based on Press & Siever book Dynamic Earth by Grozinger et al., available to ETH students via https://link.springer.com/book/10.1007/978-3-662-48342-8

751-3401-00L Plant Nutrition I W 2 credits 2V E. Frossard
Abstract
This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. The course consists of weekly lectures and bi-weekly exercises in groups.

Objective
This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts.

Content

Lecture notes
Weekly handouts of PPT slides via MyStudies

Literature
The course is based on Press & Siever book Dynamic Earth by Grozinger et al., available to ETH students via https://link.springer.com/book/10.1007/978-3-662-48342-8
Abstract
The aim of these lecture is to present the processes controlling the uptake and transport of nutrients by the plant, the assimilation of
nutrients in the plant, the effect of nutrients on crop yield and quality, the role of the soil as a source of nutrients for crops, and the basic
principles of fertilization of different crop types using mineral and organic fertilizers.

Objective
At the end of the lecture, students know how mineral nutrients are taken up through roots and circulate in the plants and what their roles in
plants are. They understand the importance of nutrients for yield formation and for crop product quality. They are able to propose
fertilization plans adapted for field crops growing under Swiss conditions.

Content
A general introduction explains the needs of appropriately managing nutrients in plant production. Afterwards, we will study the physiology
of plant nutrition (nutrient uptake by roots; nutrient transports in the plant; physiological roles of nutrients in the plant). Then the role of
nutrients for yield formation and their effects on crop quality is dealt with. Finally, the bases of crop fertilization are taught (availability of
nutrient in soil; N, P and K fertilization; different types of fertilizers).

Lecture notes
The slides will be distributed.

Literature
Marschner’s Mineral Nutrition of Plants Fourth Edition 2023, edited by Zed Rengel, Ismail Cakmak and Philip J. White; (available online on the
ETH library).

Schubert S 2011 Pflanzennährung Grundwissen Bachelor Ulmer UTB
Schweiz 8 (6), Spezialpublikation,

Methods of Statistical Data Analysis

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<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>L. Meier</td>
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Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of
variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block
designs, two-series factorial and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by
using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of
variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block
designs, two-series factorial and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an
introduction will be held.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving fostered

Social Competencies
Sensitivity to Diversity fostered

Personal Competencies
Critical Thinking fostered

401-0649-00L    | Applied Statistical Regression              | W    | 5    | 2V+1U | M. Detting |

Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical
background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily
work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear
modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual
analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable
transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model,
logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2006): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for
which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-
3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if
you have not registered for the examination of the other course unit.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

401-6215-00L Using R for Data Analysis and Graphics (Part I) W 1.5 credits 1G A. Hauser

Abstract
The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

Objective
The students will be able to use the software R for simple data analysis and graphics.

Content
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

Lecture notes
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Prerequisites / notice
The course resources will be provided via the Moodle web learning platform. Subscribing via Mystudies *automatically* makes you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=20847

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed

Social Competencies
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking assessed

401-6217-00L Using R for Data Analysis and Graphics (Part II) W 1.5 credits 1G M. Mächler

Abstract
The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions. Note: This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

Objective
The students will be able to use the software R efficiently for data analysis, graphics and simple programming

Content
The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tailoring R: options
- Extending basic R: packages

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

Lecture notes
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf
Prerequisites / notice

Basic knowledge of R equivalent to "Using R .. (part 1)" (= 401-6215-00L) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=20849

Competencies

Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Technologies: assessed

Method-specific Competencies
Analytical Competencies: assessed
Decision-making: fostered
Media and Digital Technologies: assessed
Problem-solving: assessed

Social Competencies
Communication: fostered
Cooperation and Teamwork: fostered

Personal Competencies
Adaptability and Flexibility: assessed
Creative Thinking: assessed
Critical Thinking: fostered
Self-awareness and Self-reflection: assessed
Self-direction and Self-management: fostered

Ecology and Conservation Biology

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<tr>
<td>701-0266-00L</td>
<td>Introduction to Dendrology</td>
<td>W</td>
<td>3 credits</td>
<td>3P</td>
<td>A. Rudow</td>
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Abstract
Woody plants are important elements of forest ecosystems and landscapes. The course gives an introduction to dendrology as well as to the identification of native tree and shrub species. It is a highly recommended course for the BSc specialization of Forest and Landscape and it provides the basic requirements for the consecutive course Woody Plants of Central Europe in the spring semester.

Objective
Knowledge of selected native tree and shrub species. Understanding of biological and ecological relations by means of in situ observation of woody plants. Differentiated view on forest ecosystems.

Content
Introduction to dendrology on the basis of concrete examples. Emphasis on identification of tree and shrub species (80 frequent tree and shrub species) and on the understanding of tree structure (morphology of woody plants). The illustrating way of presentation and the relations between different scale levels (organ, individual, stand, ecosystem) provide an attractive insight into forest and landscape topics as well as into environmental biology.

Lecture notes
Rudow, A., 2023: Dendrologie 1 - Folien (in German).

Literature
Rudow, A., 2011: eBot Dendrologie (Betaversion). E-learning-Tool for the support of dendrology courses at ETHZ (application integrated in eBot, in German).

Prerequisites / notice
Half of the course will be held in form of excursions and practical training in the forest (ETH Hönggerberg). Besides that 4 half day excursions (Zurich and surroundings, on weekends, dates by arrangement). Weatherproof clothes are presupposed.

The course provides the basic knowledge for the advanced course 701-0316-00L Woody Plants of Central Europe (Dendrology 2)

Competencies

Subject-specific Competencies
Concepts and Theories: fostered
Techniques and Technologies: assessed

Method-specific Competencies
Analytical Competencies: assessed
Decision-making: fostered
Problem-solving: assessed
Project Management: fostered

Social Competencies
Communication: assessed
Cooperation and Teamwork: fostered

Personal Competencies
Adaptability and Flexibility: fostered
Creative Thinking: fostered
Critical Thinking: assessed
Self-awareness and Self-reflection: assessed
Self-direction and Self-management: fostered

Vertebrate Ecology

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<tr>
<td>701-0305-00L</td>
<td>Vertebrate Ecology</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>K. Bollmann, U. Kormann</td>
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</table>

Abstract
The course covers the ecology of birds and mammals. Important concepts of nutrition, physiology, behavioural ecology, population biology, biogeography and community ecology will be linked to applications in conservation and management. A worldwide perspective will be complemented by a focus on the Central European fauna and its dynamics.

Objective
The students are familiar with important topics in animal ecology of vertebrates, with an emphasis on birds and mammals. They are able to link theoretical concepts with ecological phenomena and view them against an evolutionary backdrop. They can thus appraise applied aspects of the conservation and the use of animal populations, such as the influence of body size on the energy demand and nutrition, relationships between resource availability on habitat use of birds and mammals as well as between predators and prey species, or of herbivores on vegetation, and the effects of hunting and environmental change on animal populations. Students understand the biogeographical characteristics of the Central European vertebrate fauna and its temporal and spatial dynamics.
The course deals with a number of topics that include feeding and resource use, spatial behaviour and migrations, reproduction, population dynamics, competition and predation, parasites and diseases, biodiversity and distributions, and dynamics of the Central European fauna. There is an emphasis on linking theory with management issues in conservation and management of wildlife populations. During the first half of the course, examples will be drawn worldwide whereas during the second half, the course will focus more strongly on the European fauna, particularly of the Alpine region. Although the course is not designed to teach species knowledge and determination, examples will cover much of the taxonomic range of the European fauna.

The course includes a field excursion (7.12.2024, Alternative date: 14.12.24).

Program (Lecturers: Kurt Bollmann (KB), Urs Koramnn (UK)):
- 23.09.24 Birds and mammals: similarities & differences, endothermy & body isolation, moult in birds (KB)
- 30.09.24 Feeding I: Food, metabolism (KB)
- 07.10.24 Feeding II: Energetic needs, foraging, digestion (KB)
- 14.10.24 Distribution and habitat use, migration (UK)
- 21.10.24 Reproduction, litter and clutch size, breeding systems (UK)
- 28.10.24 Population dynamics (KB)
- 04.11.24 Predation, predator-prey-cycles (KB)
- 11.11.24 Competition (UK), Parasitism and diseases (self-study)
- 18.11.24 Biogeography of central European birds and mammals, return of ungulates and large predators (KB)
- 25.11.24 Herbivores as landscape engineers: the Serengeti ecosystem (Guest lecturer)
- 02.12.24 Exploitation of wild birds and mammals (KB)
- 09.12.24 Threats and conservation biology of selected species (UK)
- 16.12.24 Mammals and climate change (case study on roe deer) + questions and pilot test (KB)

Lecture notes
Lecture notes and handouts will be available digitally.

Literature
Some books relevant to the course are (optional reading):
- Suter, W. 2017. Ökologie der Wirbeltiere. Vögel und Säuger. UTB/Haupt, Bern. This book is based on the course. It is in German.

Competencies

<table>
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<td>Creative Thinking</td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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<td></td>
<td>fostered</td>
<td>fostered</td>
<td>Critical Thinking</td>
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</table>

701-0405-00L Rivers: Concepts and Methods for Sustainable Management

Abstract
This course deals with river ecosystems, their fundamental ecological characteristics, anthropogenic impacts and changes. We discuss concepts and interdisciplinary approaches (hydraulic engineering and ecology) for sustainable management. The students organize themselves in working groups (lecture and moderation of a discussion on a date of choice, writing of a report).

Objective
Understanding the basics of the functioning of river ecosystems:
- Basics of sustainable management of rivers
- Application of these principles to case studies
- Critical analyses, organization in discussion groups

Content
1) Planning, working groups, working methods
2) Water protection act and techniques for moderating discussions
3) Project implementation/realization
4) Floodplain management and revitalization
5) Restoration of sediment dynamics
6) Rivers under changing climate
7) River widening and ramps
8) Effects of restoration projects
9) Altered flow and temperature regimes in rivers and lakes
10) Water and health
11) Fish migration in rivers
12) Visitor control/recreational management
13) Peatland protection
14) Conclusion/evaluation

Lecture notes
Themenspezifische Unterlagen (Vorlesung Dozierende, Literatur) werden verteilt und auf Moodle zugänglich gemacht (Link folgt).

Literature
Literaturlisten zu den Gruppenarbeiten (Vortrag und Moderation einer ausgewählten Vorlesungsstunde, sowie Bericht) werden abgegeben und auf Moodle zugänglich gemacht (Link folgt).

Prerequisites / notice
Students will organize discussion groups (preparation of presentation and moderation, report).
The students are able to understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology. Students will learn about classical and latest studies in plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Critical Thinking
- Logical Thinking
- Negotiation
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Environmental Chemistry/Ecotoxicology**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
701-0201-00L | Introduction to Environmental Organic Chemistry | W | 3 credits | 2G | M. Sander, K. McNeill

**Abstract**
Important organic environmental pollutants are presented. The physical and chemical basics required for understanding the environmental behavior of such pollutants are taught and deepened in exercises.

**Objective**
- The students are able to:
  - name and recognize the most important classes of environmentally relevant anthropogenic chemicals and identify chemical moieties governing their fate processes.
  - explain, on the basis of physical-chemical foundations, the most important processes (i.e., partitioning and substitution and elimination reactions) which determine the environmental behavior of organic pollutants.
  - identify, on the basis of chemical structure, the processes relevant for the environmental behavior of a compound.
- critically evaluate published work and data.

**Content**
- Overview of the most important classes of environmental organic pollutants
- Molecular interactions that determine the partitioning behavior (adsorption and absorption processes) of organic compounds between different environmental compartments (gas, liquid, solid)
- Physical-chemical properties (vapor pressure, aqueous solubility, air-water partition constant, organic solvent-water partition constants, etc.) and partitioning behavior of organic compounds between environmentally relevant phases (air, aerosols, soil, water, biota)
- Chemical transformation reactions of organic pollutants in aquatic and in terrestrial environments (hydrolysis, elimination, addition)

**Lecture notes**
Script will be distributed

**Literature**
Organic Chemistry

Abstract
Basics of Organic Chemistry.
Reaction mechanisms in organic chemistry: substitutions, additions, eliminations, condensations, rearrangements, electrophilic aromatic substitution.

Objective
Students will be able to:
- Recall basic organic chemistry reactions, including substitution, elimination and addition reactions occurring at sp²- and sp³-hybridized carbon centers.
- Explain the relative favorability of certain organic chemical structures or certain organic chemical reactions.
- Apply their understanding of reaction mechanism principles to explain observations.
- Differentiate the most reactive sites in a given organic chemical.
- Propose reaction mechanisms to new chemical transformations.

Content
Descriptive chemistry of functional groups (alkyl halides, alkenes, aromatic systems, carbonyls).
Reaction mechanisms (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution).

Literature
Carsten Schmuck, Basisbuch Organische Chemie, Pearson

Prerequisites / notice
Der Stoff der Basischemie wird vorausgesetzt.

Biochemistry

Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo.

Objective
Students are able to describe the structure of proteins/enzymes and are able to explain biochemical functions depending on their 3D structures.

Connections between several metabolic pathways are known and students can evaluate how one pathway is influence by the activity of another pathway.

Content
Program
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design. Repetition of basic thermodynamics
Glycolysis, fermentation
The citric acid cycle
Oxidative phosphorylation and ATP physiology

Lecture notes
Horton et al. (Pearson) serves as lecture notes.

Prerequisites / notice
Basic knowledge in biology and chemistry is a prerequisite.
### Environmental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0479-00L</td>
<td>Environmental Fluid Dynamics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>H. Wernli, L. Papritz</td>
</tr>
<tr>
<td></td>
<td>Abstract: This course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.</td>
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<td>Objective: Students are able</td>
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<tr>
<td></td>
<td>- to name the basics, concepts and methods of environmental fluid dynamics.</td>
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<td>- to understand and discuss the components of the basic physical equations</td>
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<td>- to mathematically solve basic equations for simple problems of environmental fluid dynamics.</td>
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<td></td>
<td>The competencies of process understanding and system understanding are taught, applied and examined.</td>
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<tr>
<td></td>
<td>Content: Basic physical terminology and mathematical laws:</td>
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<td></td>
<td>Continuum hypothesis, forces, constitutive laws, state equations and basic principles of thermodynamics, kinematics, laws of mass and momentum on rotating earth.</td>
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<td></td>
<td>Concepts and illustrative flow systems: vorticity dynamics, boundary layers, instability, turbulence - with respect to environmental fluid systems.</td>
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<td></td>
<td>Scale analysis: dimensionless variables and dynamical similarity, simplification of the fluid system, e.g. shallow water assumption, geostrophic flow.</td>
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<td></td>
<td>Waves in environmental fluid systems.</td>
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<td></td>
<td>Lecture notes: In English language</td>
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<td></td>
<td>Literature: Will be presented in class.</td>
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<td>See also: web-site.</td>
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<tr>
<td>101-0203-01L</td>
<td>Hydraulics I</td>
<td>W</td>
<td>5</td>
<td>3V+1U</td>
<td>R. Stocker</td>
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<tr>
<td></td>
<td>Abstract: The course teaches the basics of hydromechanics, relevant for civil and environmental engineers.</td>
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<td></td>
<td>Objective: In the course &quot;Hydraulics I&quot;, the competency of process understanding is taught, applied and examined. Furthermore system understanding and measurement methods are taught.</td>
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<tr>
<td></td>
<td>Content: Properties of water, hydrostatics, stability of floating bodies, continuity, Euler equation of motion, Navier-Stokes equations, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids vs. real fluids, boundary layer, pipe flow, open channel flow, flow measurements, demonstration experiments in the lecture hall.</td>
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<td>Lecture notes: Script and collection of previous problems</td>
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<tr>
<td></td>
<td>Literature: Bolívar, Técnica Hidromecánika 1, Verlag Bauwesen, Berlin</td>
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<tr>
<td>651-3561-00L</td>
<td>Cryosphere</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Huss, D. Farinotti, H. J. Horgan</td>
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<tr>
<td></td>
<td>Abstract: The course introduces the different components of the cryosphere - snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their respective roles in the climate system. For each subsystem, essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.</td>
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<td>Objective: Students are able</td>
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<tr>
<td></td>
<td>- qualitatively explain relevant processes, feedbacks and relationships between the different components of the cryosphere,</td>
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<td>- quantify and interpret physical processes, which determine the state of the cryospheric components, with simple calculations.</td>
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<td>In the course &quot;Cryosphere&quot;, the competencies of process understanding, modeling, data analysis &amp; interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.</td>
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<td>Content: The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, permafrost, and their roles in the climate system. Essential physical aspects are emphasized for each subsystem: e.g. the material properties of ice, mass balance and dynamics of glaciers, or the energy balance of sea ice.</td>
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<td>Lecture notes: Handouts will be distributed during the teaching semester</td>
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<td>Further literature will be indicated during the lecture.</td>
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</table>
### Environmental Planning

101-0515-00 Projektmanagement and 103-0313-00 Raum- und Landschaftsentwicklung are prerequisites for the Master's degree programme in Spatial Development and Infrastructure Systems and should be successfully completed in the Bachelor's degree if possible.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0009-00L</td>
<td>Tackling Environmental Problems III</td>
<td>W</td>
<td>3 credits</td>
<td>4U</td>
<td>M. Mader, C. E. Pohl</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Students put the measures they developed during the courses Tackling Environmental Problems II into practice, in collaboration with partners from civil society, the public and the private sector.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Students are able to put the measures they developed to address sustainability problems into practice.</td>
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<tr>
<td><strong>Content</strong></td>
<td>In Tackling Environmental Problems I &amp; II, students analyze a sustainability topic, identify a specific problem within it, develop measures to address the problem and test the measures for feasibility by presenting them to concerned stakeholders. Some of the students develop their measures to such a degree, that the measures could actually be implemented. Tackling Environmental Problems III provides the opportunity to do so. Together with partners from civil society, the private and the public sector, students agree on the implementation plan, the financial and legal aspects and put the measure into practice.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Tackling Environmental Problems I &amp; II is a prerequisite for taking the course Tackling Environmental Problems III.</td>
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<tr>
<td><strong>Competencies</strong></td>
<td>Method-specific Competencies</td>
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<td></td>
<td>Decision-making</td>
<td>fostered</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td>Project Management</td>
<td>assessed</td>
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<tr>
<td><strong>Social Competencies</strong></td>
<td>Communication</td>
<td>fostered</td>
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<tr>
<td><strong>Personal Competencies</strong></td>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
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<td>Creative Thinking</td>
<td>fostered</td>
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<td>Critical Thinking</td>
<td>fostered</td>
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<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<td></td>
<td>Self-direction and Self-management</td>
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| 701-0951-00L | GIST - Introduction into Geoinformation Science and Technology | W | 5 credits | 2V+3P | M. A. M. Niederhuber |
| **Abstract** | Theoretical basics and fundamental concepts of Geographic Information Science are imparted and subsequently further elaborated with the software ArcGIS. At the end, the students will be able to independently solve basic realistic GIS problems. | | | | |
| **Objective** | Students are able to | | | | |
| | elucidate the theoretical and conceptional foundations of geographic information systems (GIS) | | | | |
| | independently perform normal GIS work using commercial software and practical examples | | | | |
| **Content** | The course covers the following topics: | | | | |
| | - What is GIS? What are spatial data? | | | | |
| | - The representation of reality by means of spatial data models: vector, raster, TIN | | | | |
| | - The four phases of data modelling: Spatial, conceptual, logical and physical model | | | | |
| | - Possibilities of data collection | | | | |
| | - Transition of reference frame | | | | |
| | - Spatial Analysis I: query and manipulation of vector data | | | | |
| | - Spatial Analysis II: operators and functions with raster data | | | | |
| | - Digital elevation models and derived products | | | | |
| | - Process modelling with vector and raster data | | | | |
| | - Presentation possibilities of spatial data | | | | |
| **Prerequisites / notice** | Aufgrund der Grösse des verfügbaren EDV-Schulungsräumes ist die Teilnehmerzahl auf 50 Studierende beschränkt! Für die Übungen werden die Studierenden auf zwei, max. drei Zeiitenfenster aufgeteilt. Pro Zeiitenfenster können maximal 25 Studierende betreut werden. | | | | |
| **Competencies** | Subject-specific Competencies | | | | |
| | Concepts and Theories | assessed | | | |
| | Techniques and Technologies | assessed | | | |
| **Method-specific Competencies** | Decision-making | assessed | | | |
| | Problem-solving | assessed | | | |
| **Social Competencies** | Cooperation and Teamwork | fostered | | | |
| **Personal Competencies** | Creative Thinking | fostered | | | |

| 701-0967-00L | Project Development in Renewable Energies | W | 2 credits | 2G | R. Rechsteiner, A. Appenzeller |

Data: 02.07.2024 12:39

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The focus is on the implementation of projects:
- photovoltaics
- wind energy
- hydropower
You will learn about new business models, including storage and sector coupling, discuss framework conditions, economic efficiency, security of supply, market organization and business risks. Guidance from experts with many years of political and project experience.

You will receive a practice-oriented introduction to the regulatory and economic requirements for renewable energy projects. You will be familiar with the opportunities and risks and strategies for economic security.

Detailed program
https://www.rechtsstner-basel.ch/lehremittel?

PPT presentation will be distributed (in German)

Literature

101-0415-01L Public Transport and Railways W 3 credits 2G F. Corman

Fundamentals of public and collective transport, in its different forms.
Categorization of performance dimensions of public transport systems, and their implications to their design and operations.

Objective

You will learn the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.
Teaches students to recognize the interactions between the infrastructure design and the production processes, and various performance criteria based on various perspective and stakeholders.

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate different choices of technologies to suitable cases; optimize the use of resources in public transport.

Content

Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings

Vehicles: Classification, design and suitability for different goals
Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.

Lecture notes

Slides, in English, are made available some days before each lecture.

Literature

Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

Prerequisites / notice

For group exercise and presentation reasons the number of participants is limited at 30 students.

For exercises students build learning and presentational groups. Credit points are based on group performance.

Competencies

Subject-specific Competencies
Concepts and Theories
- fostered

Method-specific Competencies
Analytical Competencies
- fostered

Decision-making
- fostered

Problem-solving
- fostered

Project Management
- fostered

Social Competencies
Communication
- fostered

Cooperation and Teamwork
- fostered

Customer Orientation
- fostered

Self-presentation and Social Influence
- fostered

Sensitivity to Diversity
- fostered

Personal Competencies
Creative Thinking
- fostered

Critical Thinking
- fostered

Self-awareness and Self-reflection
- fostered

Self-direction and Self-management
- fostered

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Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered


table

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<thead>
<tr>
<th>103-0313-00L</th>
<th>Spatial Planning and Landscape Development</th>
<th>W</th>
<th>5 credits</th>
<th>4G</th>
<th>G. Debrunner, S. Haulier, D. Jerjen</th>
</tr>
</thead>
</table>

Abstract
The lecture introduces the main-features of Swiss spatial planning. Core subjects are e.g., spatial planning as a federal responsibility, spatial planning instruments (federal, cantonal, municipal), as well as systematic problem solving techniques and methodologies of spatial planning. The lecture is complemented with in-depth topics and comparative international examples.

Objective
- Grundzüge der Raumplanung und ihre wichtigsten Instrumente kennenlernen
- Erarbeiten der Fähigkeit, räumliche Probleme zu erkennen und Problemlosungsverfahren auf diese anzuwenden
- Planung und Landnutzungsmanagement als interaktive und akteursbezogenen Prozess kennenlernen und anwenden
- Verstehen der mit Ressourcen und Boden verbundenen Potentiale, Nutzungen und Prozesse
- Das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Übungsaufgaben umsetzen können

Content
Die Vorlesung deckt die Grundlagen der (Schweizerischen) Raumplanung und Landschaftsentwicklung ab:
- Was ist Raumplanung (Definitionen und Begriffe)
- Aktuelle Herausforderungen, Entwicklungen und Tendenzen der Raumplanung
- Grundprinzipien, historische Entwicklung und Gesetzgebungen der Schweizer Raumplanung
- Die Raumplanung als staatliche Aufgabe – Raumordnungspolitik auf Bundesebene
- Instrumente der Raumplanung auf nationaler, kantonaler, regionaler und kommunaler Ebene (u.a. Sachpläne und Konzepte, Richtplanung, Nutzungsplanung, Sondernutzungsplanung, Mehrwertausgleich)
- Problemlösungsverfahren in der Raumplanung – systemtechnisches Vorgehen
- Thematische Vertiefungen: Siedlungsentwicklung nach innen; Klimaangepasste Raumplanung; Grundeigentum und kooperative Planung; Raumbeobachtung


Lecture notes
Skript und einzelne Dokumente werden ausgegeben. Unterlagen zur Vorlesung werden auf der SPUR-Kursseite und/oder auf Moodle direkt zur Verfügung gestellt.

Literature
• EspaceSuisse (2021): Lehrbuch Einführung in die Raumplanung, Bern.
Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Abstract
The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction to specialized project management software as well as agile project management concepts.

Objective
Projects are not only the base of work in modern enterprises, but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company-wide success.

The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project.

Content
Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

Lecture notes
No.

The lecture slides and other additional material will be available for download from Moodle a week before each class.

Competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving fostered
Project Management assessed

Social Competencies
Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility assessed
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation assessed

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management assessed

Abstract
The United Nations Agenda 2030 and its 17 Sustainable Development Goals (SDGs) provide an opportunity for the international community to shape the course of sustainable development. The lectures center on 17 sustainability and equity challenges and provide insights from researchers as well as decision makers from policy, the private sector and civil society.

Objective
1. Students know important dimensions of sustainable development and the discourse in the context of the SDGs
2. Students get an overview how ETH Zurich contributes to sustainable development and the achievement of the SDGs
3. The lecture series enables students to contribute to sustainable development during their studies and research, as graduates on the job market, and as members of the society
4. Writing a short blog post trains students to communicate acquired knowledge effectively for a broader audience.
5. Students will learn to critically read short articles and ask follow-up questions to experts of a field.

Content
For each lecture we will invite one researcher or one decision maker from policy, the private sector or civil society to reflect on one particular SDG. These talks will be followed by discussions with students and the general public. Majority of the lectures and discussion sessions will be held on campus, and some sessions online.

Lecture notes
1 short paper will be posted on the Moodle each week that should be read before the talks.

Prerequisites / notice
Open to advanced Bachelor and all Master level students enrolled at ETH Zurich
### Specialization in an Environmental System

#### Atmospheric and Climate

The following courses are highly recommended as preparation for the Specialization in Atmosphere and Climate:

- **701-0106-00L, Mathematik V: Angewandte Vertiefung von Mathematik I - III (Spring semester)**
- **402-0048-00L, Fortgeschrittene Physik für Umwelt- und ErdwissenschaftlerInnen (Spring semester)**

These courses should be successfully completed during the second year.

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0459-00L</td>
<td>Seminar for Bachelor Students: Atmosphere and Climate</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>M. Windisch, S. I. Seneviratne, O. Stebler</td>
</tr>
</tbody>
</table>

#### Content

1. **Abstract**
   - The seminar brings together students in the field of atmosphere and climate. Based on classic and current scientific articles, presentation techniques (presentations, poster presentations) are practised and students get a first insight into research in the field of atmosphere and climate.

2. **Objective**
   - In this seminar, students learn how to read scientific publications and how to transfer the scientific knowledge to a broader audience by means of oral and poster presentations. Students also get insight into the different research areas at the Institute for Atmospheric and Climate Science.

3. **Content**
   - 1st week: course organisation and presentation of the institute
   - 2nd and 3rd week: introduction to oral presentation technique
   - 4th week: 4 to 10: students talks
   - 11th week: introduction to poster presentation technique
   - 12th and 13th week: poster design
   - 14th week: concluding poster presentation

4. **Lecture notes**
   - Documents are offered via the course’s web page.

5. **Literature**
   - Documents are offered via the course’s web page.

6. **Prerequisites / notice**
   - This course can only be offered to a limited number of students, however, in any case for everybody having to attend it compulsory. We beg you to sign in to this course early.

7. **Competencies**
   - Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
   - Method-specific Competencies: Analytical Competencies, Communication
   - Social Competencies: Cooperation and Teamwork, Sensitivity to Diversity
   - Personal Competencies: Creative Thinking, Critical Thinking

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<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-0471-01L</td>
<td>Atmospheric Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Ammann, C. Heald, C. Mohr</td>
</tr>
</tbody>
</table>

#### Content

- **Abstract**
  - This course covers the chemical and physical processes controlling the composition of the troposphere and stratosphere and introduces the relevant fundamentals for processes in the gas phase, in aerosols and clouds. These concepts are explored in the context of key environmental issues, such as urban air pollution, stratospheric ozone depletion, and air quality connections to climate change.

- **Objective**
  - At the end of this course, students are able to:
    1. describe the structure of the atmosphere and list atmospheric components and their main properties
    2. define and describe the chemical and physical processes in the stratosphere and troposphere, follow reaction mechanisms, and apply rate laws
    3. describe the physical and chemical principles of air pollution and summarize the most important legislative measures
    4. discuss the local, regional, and global aspects of interactions between air quality, ecosystem health, and climate

- **Content**
  - Origin and properties of the atmosphere: composition (gases and aerosols), atmospheric structure, UV radiation, transport timescales
  - Kinetics of gas phase reactions: rate laws, mechanisms of binolecular and termolecular reactions.
  - Stratospheric chemistry: Chapman cycle, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol
  - Tropospheric chemistry: oxidizing capacity of the troposphere and the role of OH, oxidation and global budgets of CO and CH4, role of NOx, and the global tropospheric O3 budget
  - Surface ozone chemistry: HOx-NOx cycle, role of VOCs, O3 isopleth, ozone production efficiency
  - Aerosols: primary and secondary sources, composition, quantities and measures, connections to climate
  - Multiphase chemistry: solubility of gases, Raoult’s Law and hygroscopicity, kinetics of gas to particle transfer, N2O5 chemistry, aqueous phase sulfur chemistry, secondary organic aerosol formation
  - Air quality: role of planetary boundary layer, deposition processes, summer- versus winter-smog, environmental problems, legislation, long-term trends
  - Global aspects: air quality - climate interactions

- **Lecture notes**
  - Lecture materials (slides) are provided continuously during the semester, at least 2 days before each lecture. Annotations and corrections are provided at the latest within the same week.

- **Prerequisites / notice**
  - Attendance of the lecture "Atmosphäre" LV 701-0023-00L or equivalent knowledge is a pre-requisite, and basic courses in physics and chemistry are expected.
  - On Mondays (or upon agreement) a tutorial is offered. This allows the students to discuss unresolved issues from the lecture or to discuss the problems of the exercise series and their solution. Participation is recommended.
Biogeochemistry

The following courses are highly recommended as preparation for the Specialization in Biogeochemistry:

- 701-0225-00L Organic Chemistry (Autumn semester)
- 752-0100-00L Biochemie (Autumn semester)
- 752-1300-00L Introduction to Toxicology (Spring semester)

These courses should be successfully completed during the second year.

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<tr>
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<tr>
<td>701-0201-00L</td>
<td>Introduction to Environmental Organic Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Sander, K. McNeill</td>
</tr>
</tbody>
</table>
Seminar for Bachelor Students: Biogeochemistry

Objective
Current research topics are presented and discussed based on scientific literature. The students prepare a presentation with the support of an expert. Subsequently, the topics are discussed jointly by students and experts in student-moderated discussion rounds. Presentation and moderation techniques are introduced and trained in the seminar, supported by instructions for constructive feedback.

Content
- Overview of the most important classes of environmental organic pollutants
- Molecular interactions that determine the partitioning behavior (adsorption and absorption processes) of organic compounds between different environmental compartments (gas, liquid, solid)
- Physical-chemical properties (vapor pressure, aqueous solubility, air-water partition constant, organic solvent-water partition constants, etc) and partitioning behavior of organic compounds between environmentally relevant phases (air, aerosols, soil, water, biota)
- Chemical transformation reactions of organic pollutants in aquatic and in terrestrial environments (hydrolysis, elimination, addition)

Prerequisites / notice
Die Lehrveranstaltung richtet sich nicht nur an jene Studierenden, welche sich später chemisch vertiefen wollen, sondern ausdrücklich auch an alle jene, welche sich mit der Problematik von organischen Schadstoffen in der Umwelt vertraut machen wollen, um dieses Wissen in anderen Vertiefungen anzuwenden

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Restriction: only students enrolled in the environmental sciences bachelor's program can register for this course.

Deadline for enrollment is the FIRST day of the semester. Later enrollment can only be accepted in exceptional cases and under certain conditions (e.g., restricted choice of topics and dates).

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Media and Digital Technologies

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection

Soil and Water Chemistry

Abstract
This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples.
The course “Soil and Water Chemistry” teaches, applies and examines the competences process understanding, systems understanding, and modelling.

**Content**
Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.

**Literature**
--Chapters 1, 3, 4, 6, 7 and 11 in Sigg/Stumm – Aquatische Chemie, 6. Auflage, vdf, 2016.

**Prerequisites / notice**
The lecture courses Pedosphere and Hydrosphere are highly recommended.

### 701-0535-00L  Environmental Soil Physics/Vadose Zone Hydrology

**Objective**
The course provides theoretical and practical foundations for understanding and characterizing physical soil properties and processes and their relevance for terrestrial ecosystems, plant growth, hydrological processes and atmospheric-land gas exchange, across all relevant scales.

**Content**
1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants.
2. Quantitative applications of chemical equilibria to processes in natural systems.

**Literature**

**Problem-solving Techniques and Technologies**
3 credits  2V+1U  A. Carminati, P. U. Lehmann Grunder

**Abstract**
The course provides theoretical and practical foundations for understanding and characterizing physical soil properties and processes and their relevance for terrestrial ecosystems, plant growth, hydrological processes and atmospheric-land gas exchange, across all relevant scales.

**Objective**
- Characterize the different soils based on their key textural and structural properties.
- Simulate and predict soil water retention and flow under varying environmental conditions and understand the key driving forces (capillarity, gravity, friction) and related water properties (surface tension and viscosity).
- Predict soil hydraulic properties for varying soil textural classes.
- Predict solute transport in soils for varying environmental conditions.
- Predict energy balance and temperature dynamics in soils.
- Predict conditions for plant water stress.
- Estimate the impact of soil properties on the hydrological cycle and on plant growth.

**Contents**
**INTRODUCTION**
Week 1 (September 18)
Presentation of the role of soil physics in environmental sciences and terrestrial ecosystems: soils in the water cycle; soils and vegetation; soils and solute transport. Survey on students' interests and expectations. Presentation of course structure and learning objectives.

**BASE SOIL PROPERTIES**
Week 2 (September 25) and Week 3 (October 02)
- soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density
- Pore scale consideration (water in a single pore), pore sizes and shapes; surface tension; Young-Laplace equation; capillary rise; contact angle
- Friction and laminar flow; Hagen-Poiseuille's law; Washburn equation; numerical lab (REPORT 1)

**SOIL HYDRAULIC PROPERTIES**
Week 4 (October 09) and Week 5 (October 16)
- Soil water content and soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point
- Soil water characteristics and pore size distribution
- Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts; effective conductivity; unsaturated hydraulic conductivity; Buckingham law.
- Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications

**TOOLBOX – MEASUREMENTS AND MODELING**
Week 6 (October 23) and Week 7 (October 30)
- Measuring soil hydraulic properties, fitting and interpretation; Lab tour - demonstration of soil physical methods; lecture on HYPROP method; report on Hyprop data (REPORT 2)
- Modelling unsaturated water flow based on Richards equation - Using Hydrus1D for simulation of unsaturated flow; simulating HYPROP measurements (REPORT 3)

**SOIL IN THE WATER CYCLE**
Week 8 (November 06) – Week 9 (November 13)
- Water infiltration - steady state solutions for infiltration; approximate solutions to infiltration (Green-Ampt, Philip); infiltration rate and ponding; outlook to preferential flow
- Water evaporation - Energy balance and land atmosphere interactions - potential and actual evaporation, evaporation stages;

**SOIL-PLANT INTERACTIONS**
Week 10 (November 20) Week 11 (November 27)
- Root water uptake and transpiration – Theory and mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance.
- Modelling root water uptake and transpiration; analytical approaches and modeling using Hydrus (REPORT 4)

**SOLUTE TRANSPORT**
Week 12 (December 04) Week 13 (December 11)
- Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application
- Transport of reactive substances, preferential flow, simulations with Hydrus

**CLOSURE**
Week 14 (December 18)
Summary, course synthesis, connections between the different topics, questions, exam preparation

**Literature**
Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

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### Human-Environment Systems

The following courses are highly recommended as preparation for the Specialization in Human-Environment Systems:

- 401-0625-01L **Applied Analysis of Variance and Experimental Design**
- 401-0649-00L **Applied Statistical Regression**

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<tr>
<td>701-0658-00L</td>
<td>Seminar for Bachelor Students: Human Environment Systems</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>J. W. McCaughey, A. Berthold, E. Lieberherr</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Analysis and presentation of research papers from the involved chairs, relating to topics from human-environment systems.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The students learn to read, understand, summarize and present current research papers related to human-environment systems. Furthermore, students train the critical discussion of these papers. The students also get to know a number of innovative approaches for such presentations.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Research in human-environment systems is characterised by a broad range of topics and methods. This is illustrated by the research papers that are discussed in this seminar. Students choose a paper from a list and present it to the seminar participants. Furthermore, they lead the discussion and train questions and answers related to such presentations. In the first three lessons, inputs to presentation techniques and innovative approaches to presentations are provided and discussed.</td>
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<td><strong>Lecture notes</strong></td>
<td>Will be provided in the seminar.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Will be provided in the seminar.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Method-specific Competencies: Analytical Competencies, Decision-making, Problem-solving, Project Management</td>
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<td></td>
<td>Social Competencies: Communication, Cooperation and Teamwork, Leadership and Responsibility</td>
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<td>Personal Competencies: Adaptability and Flexibility, Creative Thinking, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management</td>
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<tr>
<td>363-0537-00L</td>
<td>Resource and Environmental Economics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>A. Miftakhova, A. Minabutdinov</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainable technologies, environmental economics, and international resource and environmental problems.</td>
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<td><strong>Objective</strong></td>
<td>A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, we discuss the issues of free-rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.</td>
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<td><strong>Competencies</strong></td>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
</tr>
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Autumn Semester 2024

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Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

851-0577-00L Principles of Political Science

Abstract
This course deals with basic questions, concepts, theories, methods, and empirical findings of political science.

Objective
This course deals with basic questions, concepts, theories, methods, and empirical findings of political science.
The following courses are highly recommended as preparation for the Specialization in Environmental Biology:

- 227-0399-10L, Physiology and Anatomy for Biomedical Engineers I (Autumn semester)
- 551-0448-00L, Zoologie (Spring semester)
- 701-0360-00L, Systematische Biologie: Pflanzen (Spring semester)
- 227-0398-10L, Physiology and Anatomy for Biomedical Engineers II (Spring semester)

These courses should be successfully completed during the second year.

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<td>701-0301-00L</td>
<td>Applied Systems Ecology</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Gessler</td>
</tr>
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</table>

This course provides the ecological systems’ knowledge needed to question applied solutions to current environmental issues. Our central aim is to balance participants’ respect for complexity with a sense of possibility by providing examples from the vast solution space offered by ecological systems, such as e.g. green infrastructure to manage water.
At the end of the course you will:
...you know how to structure your inquiry and how to proceed the analysis when faced with a complex environmental issue. You can formulate the relevant questions, find answers (supported by discussions, input from the lecturers and the literature), and you are able to present your conclusions clearly and cautiously.

...you understand the complexity of interactions and structures in ecosystems. You know how ecosystem processes, functions and services interact and feed back across multiple spatio-temporal scales (in general, plus in depth case examples).

...you understand that biodiversity and the interaction between organisms are an integral part of ecosystems. You are aware that the link between biodiversity and process/function/service is rarely fully understood. You know how to honestly deal with this lack of understanding and can nevertheless find, critically analyse and communicate solutions.

...you understand the importance of ecosystem services for society.

...you have an overview of the methods of ecosystem research and have a deeper insight into some of them, e.g. ecosystem observation, manipulation and modelling.

...you have reflected on ecology as a young discipline at the heart of significant applied questions.

This course provides the ecological systems' knowledge needed to question applied sustainability solutions. We will critically assess the complexity of current environmental issues, illustrating basic ecological concepts and principles. Our central aim is to balance participants' respect for complexity with a sense of possibility by providing examples from the vast solution space offered by ecological systems, such as e.g. green infrastructure to manage water.

The course is structured around four larger topical areas: (1) Integrated Water Management -- Green infrastructure (land management options) as an alternative to engineered solutions (e.g. large reservoirs) in flood and drought management; (2) Fire dynamics, the water cycle and biodiversity -- The surprising dynamics of species life cycles and populations in arid landscapes; (3) Rewilding, e.g. re-introducing apex predators (e.g. wolves), or large ungulates (e.g. bison) in protected areas -- A nature conservation trend with counterintuitive effects; (4) Coupling of aquatic and terrestrial systems: carbon, nitrogen and phosphorus transfers of global importance on landscape scale.

Case descriptions, commented glossary and a list of literature and further resources per case.


Schulze et al. (2005) Plant Ecology; Springer.

The course combines elements of a classic lecture, group discussions and problem based learning. It is helpful, but not essential to be familiar with the "seven stages" method (see e.g. course 701-0352-00L "Analysis and Assessment of Environmental Sustainability" by Christian Pohl et al.).

In this course, students will:
- Understand the theoretical underpinnings of conservation and restoration science.
- Consider alternative conservation concepts and approaches, and the role of science and evidence in implementing these ideas in practice.
- Appraise different conservation strategies, drawing on case studies and examples from around the world.
- Explore new and emerging technologies that can be useful to guide responsible decision making in land management decisions.
- Evaluate the future direction of conservation science, in terms of new concepts (resilience, restoration, rewilding, natural capital, decoupling) and emerging technologies (remote sensing, AI, genetics).
- Explore conservation and restoration science and practice in the context of current societal pressures, and the prospects for biodiversity conservation in coming decades.
- Understand how responsible restoration and conservation goals should integrate local practices, customs, cultures, and economic requirements.

In this course, students will:
- Learn about the historical development of thinking in conservation and restoration ecology.
- Learn about the ecological theories underpinning conservation and restoration ecology.
- Learn about emerging statistical and analytical tools to guide effectively responsible conservation and restoration initiatives.
- Learn about the practical challenges and trade-offs in decision making that ultimately govern the success of conservation and restoration challenges around the world.
- Understand, through the exploration of case studies and site visits, differing normative and management perspectives on landscape scale conservation and restoration.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2463 of 2667
2021 marked the start of the UN Decade on ecosystem restoration, a global initiative to conserve and restore nature for the benefit of climate change, biodiversity and human wellbeing. As an emerging workforce enters this exponentially growing field, we hope that they will be armed with the fundamental principles that are necessary to enhance the likelihood of success.

Conservation and restoration science is a relatively young discipline, yet it has undergone substantial change in recent decades on account of changing environmental realities, new conceptual framings, and opportunities afforded by emerging technologies. As a rapidly evolving discipline, with considerable relevance and impact to environment, policy, and society, it is essential that environmental science students understand the role of science for conservation practice.

This course will explore how science and technology provides the conceptual structure and knowledge base for new approaches to conservation of biodiversity, habitats, and resources. The course will begin by examining the theoretical foundations of conservation science, and how these concepts have developed over the past century. It will examine alternative approaches to conservation ranging from traditional protected area and wildlife management systems, through to more recent concepts and approaches, including ecosystem services, natural capital, restoration, and rewilding. It will emphasize the role of new technological and analytical methods, including Earth observation, monitoring systems, AI, and genetics. Finally, the students will use a horizon scanning approach to determine the future opportunities, priorities, and constraints for conservation science and practice in our rapidly changing world.

Students will evaluate several general questions, including:
- What is conservation, and what do we want to conserve?
- What ecological theories frame conservation and restoration practice, and how can science guide conservation decisions?
- What new concepts (ecological, societal, economical) shape conservation and restoration theory and practice, and what conflicts do they engender?
- What prospects does technology offer for future conservation and restoration efforts?

Ecosystem Conservation and Restoration will provide an excellent foundation on how theoretical and applied natural and social sciences are, and can be, coupled to emerging technologies and data science to conserve and restore biodiversity and ecological functions in landscapes. For students wishing to acquire a deeper level of understanding of both science and practice in conservation and restoration, this course will serve as the prerequisite for a two-week Masters-level field course (tentatively titled Conservation, Restoration, and Landscape Management) to Scotland, being developed by the Ghazoul and Crowther labs and planned for 2023. The field course will challenge students to apply the conceptual and technical understanding gained from the Ecosystem Conservation and Restoration course, specifically by working with a variety of stakeholders involved in selected forest and landscape restoration processes in Scotland.

Content

- **2021 marked the start of the UN Decade on ecosystem restoration, a global initiative to conserve and restore nature for the benefit of climate change, biodiversity, and human wellbeing.**
- As an emerging workforce enters this exponentially growing field, we hope that they will be armed with the fundamental principles that are necessary to enhance the likelihood of success.
- Conservation and restoration science is a relatively young discipline, yet it has undergone substantial change in recent decades on account of changing environmental realities, new conceptual framings, and opportunities afforded by emerging technologies. As a rapidly evolving discipline, with considerable relevance and impact to environment, policy, and society, it is essential that environmental science students understand the role of science for conservation practice.
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Lecture notes
Handouts will be provided electronically.

Prerequisites / notice
Recommendation: We recommend that you also follow the course 701-1413-00L - Population and Quantitative Genetics either in advance or in parallel.

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies fostered
- Critical Thinking fostered

Personal Competencies

Forest and Landscape
The following courses are highly recommended as preparation for the Specialization in Forest and Landscape:

701-0266-00L Einführung in die Dendrologie (Autumn semester)
701-0951-00L GIST - Einführung in die räumlichen Informationswissenschaften und -technologien (Autumn Semester)
551-0448-00L Zoologie (Spring semester)
701-0360-00L Systematische Biologie: Pflanzen (Spring semester)

These courses should be successfully completed during the second year.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0535-00L</td>
<td>Environmental Soil Physics/Vadose Zone Hydrology</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>A. Carminati, P. U. Lehmann Grunder</td>
</tr>
</tbody>
</table>

Abstract
The course provides theoretical and practical foundations for understanding and characterizing physical soil properties and processes and their relevance for terrestrial ecosystems, plant growth, hydrological processes and atmospheric-land gas exchange, across all relevant scales.

Objective
Students are able to:
- Characterize the different soils based on their key textural and structural properties.
- Simulate and predict soil water retention and flow under varying environmental conditions and understand the key driving forces (capillarity, gravity, friction) and related water properties (surface tension and viscosity).
- Predict soil hydraulic properties for varying soil textural classes.
- Predict solute transport in soils for varying environmental conditions.
- Predict energy balance and temperature dynamics in soils.
- Predict conditions for plant water stress.
- Estimate the impact of soil properties on the hydrological cycle and on plant growth.

Content
INTRODUCTION
Week 1 (September 18)
- Presentation of the role of soil physics in environmental sciences and terrestrial ecosystems: soils in the water cycle; soils and vegetation; soils and solute transport. Survey on students’ interests and expectations. Presentation of course structure and learning objectives.

BASIC SOIL PROPERTIES
Week 2 (September 25) and Week 3 (October 02)
- soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density
- Pore scale consideration (water in a single pore), pore sizes and shapes; surface tension; Young-Laplace equation; capillary rise; contact angle
- Friction and laminar flow; Hagen-Poiseuille’s law; Washburn equation; numerical lab (REPORT 1)

SOIL HYDRAULIC PROPERTIES
Week (4 October 09) and Week 5 (October 16)
- Soil water content and soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point
- Soil water characteristics and pore size distribution
- Saturated water flow in soils - Laminar flow in tubes (Poiseuille’s Law); Darcy’s Law; conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts; effective conductivity; unsaturated hydraulic conductivity; Buckingham law.
- Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications

TOOLBOX – MEASUREMENTS AND MODELING
Week (6 October 23) and Week 7 (October 30)
- Measuring soil hydraulic properties, fitting and interpretation; Lab tour - demonstration of soil physical methods; lecture on HYPROP method; report on Hyprop data (REPORT 2)
- Modelling unsaturated water flow based on Richards equation - Using Hydrus1D for simulation of unsaturated flow; simulating HYPROP measurements (REPORT 3)

SOIL IN THE WATER CYCLE
Week 8 (November 06) – Week 9 (November 13)
- Water infiltration - steady state solutions for infiltration; approximate solutions to infiltration (Green-Ampt, Philip); infiltration rate and ponding; outlook to preferential flow
- Water evaporation - Energy balance and land atmosphere interactions - potential and actual evaporation, evaporation stages;

SOIL PLANT INTERACTIONS
Week 10 (November 20) Week 11 (November 27)
- Root water uptake and transpiration – Theory and mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance.
- Modelling root water uptake and transpiration; analytical approaches and modeling using Hydrus (REPORT 4)

SOLUTE TRANSPORT
Week 12 (December 04) Week 13 (December 11)
- Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application
- Transport of reactive substances, preferential flow, simulations with Hydrus

CLOSURE
Week 14 (December 18)
- Summary, course synthesis, connections between the different topics, questions, exam preparation

Literature
Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel
### Competencies

<table>
<thead>
<tr>
<th>701-0553-00L</th>
<th>Landscape Ecology</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>L. Pellissier, F. Fopp, S. Gradinaru</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The course is an introduction to Landscape Ecology and Landscape Modelling and provides various practical applications of Landscape Ecology in nature and landscape management.</td>
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</tbody>
</table>
| **Objective** | The students are able:  
  - to explain and apply the concepts and methods of landscape analysis using examples,  
  - to explain causes and effects of changes in landscape using examples and simulations,  
  - to describe practical applications of Landscape Ecology in the management of nature and landscape. |
| **Content** | Contents of the lecture:  
  - important terms and concepts of Landscape Ecology,  
  - analysis of landscape pattern (metrics),  
  - landscape modelling,  
  - perception of landscapes,  
  - application of landscape ecology concepts in planning. |
| **Lecture notes** | The course is offered via a MOOC (Edx) and Moodle Course. |
| **Literature** | listet in the MOOC |
| **Prerequisites / notice** | This lecture is coordinated with a MOOC. It is advantageous but not required to have some R programming and GIS knowledge for this lecture and the practical "Praktikum Wald und Landschaft" (spring semester) which is loosely linked with this lecture. |
| **Competencies** | Subject-specific Competencies: Concepts and Theories assessed, Techniques and Technologies assessed.  
  Method-specific Competencies: Analytical Competencies assessed, Decision-making assessed, Problem-solving assessed, Project Management fostered. |
| **701-0559-00L | Seminar for Bachelor Students: Forest and Landscape | W | 3 credits | 2S | M. Lévesque, E. Lieberherr |
| **Abstract** | Interdisciplinary seminar on forest and landscape issues with particular emphasis on the key processes shaping the development of forest ecosystems and landscapes. Students perform literature researches, and train presentation and moderation techniques as well as a constructive feedback culture. |
| **Objective** | - To critically analyze and discuss original scientific articles for selected processes and methods in relation to forest and landscape.  
  - Scientific exchange with subject-specific experts.  
  - Learn standard rhetoric and moderation methods through training in the seminar.  
  - Effective feedback regarding the independent development of presentation and moderation competencies. |
| **Content** | Seminars will deal with the following topics: 1) Biological, ecological and physical processes, and technical aspects in forest ecosystems with effects on the community, ecosystem and landscape; 2) Social and political processes and institutions with relation to land use; 3) Products and services of forest ecosystems and landscapes and 4) Forest management systems. The contributions will be grouped by topics. Furthermore, the seminar teaches rhetoric and moderation methods, which will serve to deepen the above topics through presentations and discussions. |
| **Lecture notes** | There will be a script for the rhetoric and moderation methods. |
| **Literature** | Literature references will be provided by the lecturers. |
| **Prerequisites / notice** | The credits are assigned if the following requirements are met:  
  a) Independent literature research on the topic and exchange with experts for preparing for the presentation  
  b) Presentation with questions and answers (15-20 min)  
  c) Moderation of the scientific discussion (20-35 min)  
  d) Actively contributing to the feedback of students' presentations, moderation and discussions. |
| **Competencies** | Subject-specific Competencies: Concepts and Theories assessed, Techniques and Technologies assessed.  
  Method-specific Competencies: Decision-making assessed, Problem-solving assessed.  
  Social Competencies: Communication assessed, Cooperation and Teamwork assessed, Self-presentation and Social Influence assessed, Sensitivity to Diversity assessed.  
  Personal Competencies: Adaptability and Flexibility fostered, Creative Thinking fostered, Critical Thinking fostered, Integrity and Work Ethics fostered, Self-awareness and Self-reflection fostered, Self-direction and Self-management fostered. |
| **701-0561-00L | Forest Ecology | W | 3 credits | 2V | H. Bugmann |
| **Abstract** | This course conveys the basics of forest ecology with an emphasis on those organisms that dominate the physiognomy and the dynamics of forest ecosystems. Based on this course, students have a good grasp of the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with a focus on central Europe. |
Objective

Students are able to
- summarize the fundamentals of forest ecology at the autecological, demeological and synecological level
- explain how trees dominate the physiognomy and dynamics of forest ecosystems
- describe the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with an emphasis on central Europe and Alpine region.

Overall, the competences of process understanding, system understanding, modeling, concept development and data analysis & interpretation will be discussed throughout the course.

Content

Introduction and overview of the forests of the world
Forest ecosystem ecology: Production ecology of forests
Autecology: light, temperature, wind, water, and nutrients
Demeology: regeneration ecology, forest growth, mortality

Lecture Notes

Handouts are available for download from https://fe.ethz.ch/studium/lehrmaterialien/bachelor/waldoekologie.html.

Prerequisites / notice

The contents of the following courses of the 2nd year of the USYS BSc are required:

- Pedosphere, Hydrosphere, Fundamentals of biology and ecology, Introduction to dendrology (knowledge of European tree species).
- Analytical Competencies
- Method-specific Competencies
- Personal Competencies
- Subject-specific Competencies
- Critical Thinking

ECTS 3 credits

701-0565-00L Principles of Natural Hazard Management

Lecturers

A. Ringenbach

Literature


Prerequisites / notice

Students are able to
- identify and discuss the development of natural hazards in the context of climate change.
- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- By the end of the course, students will be able to:

Literature


Prerequisites / notice

Bachelor's Thesis

In principle, all professors and lecturers involved in the teaching of the Environmental Sciences degree programme are entitled to supervise a Bachelor's thesis (BA). BA in the area of social sciences and humanities can only be supervised by lecturers who teach in this area. The same applies to BA in the field of natural sciences and technology.

Bachelor's Thesis

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**Abstract**

Students learn (a) to work on a question using scientific methods and concepts, (b) to write a report according to scientific standards and (c) to correctly cite knowledge from the literature. Depending on the orientation of the work, they learn this by means of an empirical investigation, a literature study, a planning task or a practical project.

**Objective**

With the Bachelor's thesis, students learn (a) to work on a problem using scientific methods and concepts, (b) to write a report according to scientific standards and (c) to correctly cite knowledge from the literature.

**Content**

The Bachelor's thesis is written either in the area of "Social Sciences and Humanities" or in the area of "Natural Sciences and Technology". It can also be interdisciplinary and transdisciplinary.

A Bachelor's thesis in the field of "Social Sciences and Humanities" usually deals with a question at the interface of these sciences and the environment and sustainability. Social science and humanities methods of data collection, analysis and interpretation are used.

A Bachelor's thesis in the field of "Natural Sciences" deals with a topic at the interface of the natural sciences and the environment and sustainability. Natural science methods of data collection, analysis and interpretation are used.

A thesis in the field of "technology" deals with the environmental impact of a use. It can be an analysis, an assessment or the future design of a use.

In interdisciplinary or transdisciplinary work, findings from different disciplines are brought together on the basis of an overarching question, or social actors are included in the work.

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### Environmental Sciences Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
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<th>Letter</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Environmental Sciences Master

► Major in Atmosphere and Climate

►► Prerequisites

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>701-0471-01L</td>
<td>Atmospheric Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Ammann, C. Heald, C. Mohr</td>
</tr>
</tbody>
</table>

**Abstract**
This course covers the chemical and physical processes controlling the composition of the troposphere and stratosphere and introduces the relevant fundamentals for processes in the gas phase, in aerosols and clouds. These concepts are explored in the context of key environmental issues, such as urban air pollution, stratospheric ozone depletion, and air quality connections to climate change.

**Objective**
At the end of this course, students are able to:
1. describe the structure of the atmosphere and list atmospheric components and their main properties
2. define and describe the chemical and physical processes in the stratosphere and troposphere, follow reaction mechanisms, and apply rate laws
3. describe the physical and chemical principles of air pollution and summarize the most important legislative measures
4. discuss the local, regional, and global aspects of interactions between air quality, ecosystem health, and climate

**Content**
- Origin and properties of the atmosphere: composition (gases and aerosols), atmospheric structure, UV radiation, transport timescales
- Kinetics of gas phase reactions: rate laws, mechanisms of bimolecular and termolecular reactions.
- Stratospheric chemistry: Chapman cycle, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol
- Tropospheric chemistry: oxidizing capacity of the troposphere and the role of OH, oxidation and global budgets of CO and CH4, role of NOX, and the global tropospheric O3 budget
- Surface ozone chemistry; HOx-NOx cycle, role of VOCs, O3 isopleth, ozone production efficiency
- Aerosols: primary and secondary sources, composition, quantities and measures, connections to climate
- Multiphase chemistry: solubility of gases, Raoult’s Law and hygroscopicity, kinetics of gas to particle transfer, N2O5 chemistry, aqueous phase sulfur chemistry, secondary organic aerosol formation
- Air quality: role of planetary boundary layer, deposition processes, summer- versus winter-smog, environmental problems, legislation, long-term trends
- Global aspects: air quality - climate interactions

**Lecture notes**
Lecture materials (slides) are provided continuously during the semester, at least 2 days before each lecture. Annotations and corrections are provided at the latest within the same week.

**Prerequisites / notice**
Attendance of the lecture “Atmospheric” LV 701-0023-00L or equivalent knowledge is a prerequisite, and basic courses in physics and chemistry are expected.
On Mondays (or upon agreement) a tutorial is offered. This allows the students to discuss unresolved issues from the lecture or to discuss the problems of the exercise series and their solution. Participation is recommended.

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Creative Thinking

| 701-0473-00L | Weather Systems                  | W    | 3 credits | 2G    | M. A. Sprenger, I. Thurnherr |

**Abstract**
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes

**Objective**
The students are able to:
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- explain how mountain influence the atmospheric flow on different scales
- basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems
- explain the structures of the atmosphere and list atmospheric components and their main properties

**Content**
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

**Lecture notes**
Lecture notes and slides

**Literature**
Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

**Prerequisites / notice**
Basic physics

**Competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Creative Thinking

| 701-0475-00L | Atmospheric Physics              | W    | 3 credits | 2G    | U. Lohmann                     |

**Abstract**
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, especially prediction of showers and severe convective storms, and optical phenomena

**Objective**
Students are able to:
- to explain the mechanisms of convective storm formation using knowledge of thermodynamics and cloud microphysics.
- to interpret precipitation radar images
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

In the course “Atmospheric Physics”, the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined. Measurement methods are taught as well.
The course starts with introducing selected concepts of thermodynamics for atmospheric processes. The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to use thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in radiosonde ascents. Atmospheric mixing processes are introduced as a basis for fog formation. The concept of an air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation (convective vs. stratiform) are discussed and how they can be identified in radar images. Students will also learn under which conditions severe convective storms (especially supercells with tornados) can form.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Lecture notes
Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=22731

Literature

An electronic version of this book can be obtained via the ETH library.

pdf-files of the revised book will be provided on moodle on a chapter-by-chapter basis.

We offer a lab tour in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Problem-solving: assessed

Social Competencies
- Communication: assessed

Personal Competencies
- Critical Thinking: assessed
- Self-direction and Self-management: assessed

 Mia C. M. Schär, A. P. Del Genio, P. J.以後

Autumn Semester 2024

Mandatory Courses

Introduction Course

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1213-00L</td>
<td>Introduction Course to Master Studies Atmosphere and Climate</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>H. Joos</td>
</tr>
</tbody>
</table>

Abstract
New master students are introduced to the atmospheric and climate research field through keynotes given by the programme's professors. In several self-assessment and networking workshops they get to know each other and obtain general information and guidance about the organisation of the MSc programme.

Objective
The aims of this course are i) to welcome all students to the master program and to ETH, ii) to acquaint students with the faculty teaching in the field of atmospheric and climate science at ETH and at the University of Bern, iii) that the students get to know each other and iv) to assess needs and discuss options for training and education of soft-skills during the Master program and to give an overview of the study options in general.

Competencies
Subject-specific Competencies
- Concepts and Theories: fostered

Method-specific Competencies
- Decision-making: fostered

Personal Competencies
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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Abstract
The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions.

Objective
The students are exposed to different atmospheric science topics and learn how to take part of the scientific discussions.

Competencies
Subject-specific Competencies
- Concepts and Theories: fostered

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Competencies
Subject-specific Competencies
- Concepts and Theories: fostered
In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis. Participation is mandatory. The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions. The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions. In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

### Seminars

**701-1211-01L Master's Seminar: Atmosphere and Climate 1**
- **Type**: O
- **ECTS**: 3
- **Hours**: 2S
- **Lecturers**: H. Joos, R. Knutti, A. Merrifield König, M. A. Wüest

**Abstract**
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

**Objective**
Training scientific writing skills.

**Content**
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

**Prerequisites / notice**
Attendance is mandatory.

**701-1211-02L Master's Seminar: Atmosphere and Climate 2**
- **Type**: O
- **ECTS**: 3
- **Hours**: 2S
- **Lecturers**: H. Joos, R. Knutti, A. Merrifield König, M. A. Wüest

**Abstract**
In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis. Participation is mandatory. The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions. The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions. In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

**Objective**
Apply scientific project management techniques to your master project, practice the presentation of scientific results and how to chair other students presentations and lead the discussion.

**Content**
In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis.

**Prerequisites / notice**
Attendance is mandatory.

**Weather Systems and Atmospheric Dynamics**

**701-1221-00L Dynamics of Large-Scale Atmospheric Flow**
- **Type**: W
- **ECTS**: 4
- **Hours**: 2V+1U
- **Lecturers**: H. Wernli, J. Riboldi

**Abstract**
This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

**Objective**
Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

**Content**
Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

**Lecture notes**
Dynamics of large-scale atmospheric flow

**Literature**
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

**Prerequisites / notice**
Physics I, II, Environmental Fluid Dynamics

**Competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Assessed

- **Method-specific Competencies**
  - Analytical Competencies
  - Assessed
  - Problem-solving
  - Assessed

- **Social Competencies**
  - Cooperation and Teamwork
  - Assessed

- **Personal Competencies**
  - Critical Thinking
  - Assessed

**651-4053-05L Boundary Layer Meteorology**
- **Type**: W
- **ECTS**: 4
- **Hours**: 3G
- **Lecturers**: M. Rotach, P. Calanca

**Competencies**

- **Subject-specific Competencies**
  - Critical Thinking
  - Assessed

**Prerequisites / notice**
Physics I, II, Environmental Fluid Dynamics

**Literature**
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

**Objective**
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**Prerequisites / notice**
Attendance is mandatory.
Abstract
The Planetary Boundary Layer (PBL) constitutes the lower part of the atmosphere, is characterized by turbulent mixing and ensures the exchange of energy, mass and momentum between the Earth’s surface and the atmosphere. The course provides the theoretical background for understanding the structure and dynamics of the PBL. Idealized concepts are reviewed and contrasted to real world applications.

Objective
Students are able to:
- Name the basic approaches needed to describe planetary boundary layer flows and associated turbulent exchange processes.
- Apply these concepts to answer comprehension questions and solve simple problems related to the structure and dynamics of the PBL.
- Independently judge the applicability of learned concepts and tools to real-world situations.

Content
- Introduction
- PBL structure and stability
- Turbulence and turbulent transport
- Scaling and similarity theory
- Spectral characteristics
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Rough surfaces and the roughness sublayer
- Complex terrain

Lecture notes available (i.e. in English)

Literature

Prerequisites / notice
Umwelt-Fluidodynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Competencies

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<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
<td>fostered</td>
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<td>Decision-making</td>
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<tr>
<td>Problem-solving</td>
<td>fostered</td>
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<tr>
<td>Creative Thinking</td>
<td>fostered</td>
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Personal Competencies
Creative Thinking

Climate Processes and Feedbacks

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<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>701-1235-00L</td>
<td>Cloud Microphysics</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>Z. A. Kanji, J. Chen, C. Zhang</td>
</tr>
</tbody>
</table>

The lecture takes place if a minimum of 7 students register for it.

Priority is given to PhD students majoring in Atmospheric and Climate Sciences, and remaining open spaces will be offered to the following groups:
- Msc in Atmospheric and Climate Science
- MSc in Environmental Sciences
- Fachstudent, University of Bern / MSc in Climate Sciences, University of Bern
- Mobility-Students: Earth and Climate Sciences
- Mobility-Students: Environmental Sciences

All participants will be on the waiting list at first. All students will be informed on September 18th, 2023, if they can participate in the lecture. Students still on the waiting list on September 18, are nonetheless encouraged to come to the introductory lecture on September 19. If more spaces become available later in the week due to drop outs, waitlisted students will be accepted into the course.

Abstract
Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes.

Objective
The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles to interpret atmospheric observations of clouds and precipitation.

Content
see: http://www.iac.ehtz.ch/edu/courses/master/modules/cloud-microphysics.html
and: https://moodle-app2.let.ehtz.ch/course/view.php?id=15424

Lecture notes
This course will be designed as a reading course in 1-2 small groups of 10-12 students maximum. It will be based on the textbook below. The students are expected to read chapters of this textbook prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth. Check the course website for lecture dates and location.

Literature
Lamb and Verlinde: PHYSICS AND CHEMISTRY OF CLOUDS, Cambridge University Press, 2011

Prerequisites / notice
Target group: Doctoral and Master students in Atmosphere and Climate. A couple spots will be reserved for mobility students.

Competencies

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<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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701-1251-00L | Land-Climate Dynamics | W | 3 | 2G | S. I. Seneviratne, R. Padron Flasher, P. Sieber

Abstract
The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

Objective
The students can understand the role of land processes and associated feedbacks in the climate system.

Lecture notes
Powerpoint slides will be made available
Atmospheric Composition and Cycles

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<tr>
<td>701-1239-00L</td>
<td>Aerosols I: Physical and Chemical Principles</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>M. Gysel Beer, D. Bell, E. Weingartner</td>
</tr>
</tbody>
</table>

Abstract
Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

Objective
Physical and chemical principles:
The students...
- know the processes and physical laws of aerosol dynamics.
- understand the thermodynamics of phase equilibria and chemical equilibria.
- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:
The students...
- know the most important chemical and physical measurement instruments.
- understand the underlying chemistry and physics.

Environmental impacts:
The students...
- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
- know the most important climate impacts of atmospheric aerosols.
- are aware of the health impacts of atmospheric aerosols.

Lecture notes
Material is distributed during the lecture

Literature

Competencies
- Subject-specific Competencies: Concepts and Theories - assessed, Techniques and Technologies - assessed
- Method-specific Competencies: Analytical Competencies - assessed, Decision-making - fostered, Media and Digital Technologies - fostered, Problem-solving - assessed, Project Management - fostered
- Personal Competencies: Adaptability and Flexibility - fostered, Creative Thinking - assessed, Critical Thinking - fostered, Integrity and Work Ethics - fostered, Self-awareness and Self-reflection - fostered, Self-direction and Self-management - fostered

Climate History and Paleoclimatology

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<tr>
<td>651-4057-00L</td>
<td>Climate History and Palaeoclimatology</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>H. Stoll, I. Hernández Almeida</td>
</tr>
</tbody>
</table>

Abstract
Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

Objective
The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.
The course spans 5 thematic modules:

1. **Cyclic variation in the earth's orbit and the rise and demise of ice sheets.** Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. **Feedbacks on climate cycles from CO2 and methane.** What drives CO2 and methane variations over glacial cycles? What are the feedbacks of ocean circulation and the terrestrial biosphere?

3. **Atmospheric circulation and variations in the earth's hydrological cycle.** How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. **Century-scale droughts and civil catastrophes.** Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. **How sensitive is Earth's long term climate to CO2 and cloud feedbacks?** What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

### Competencies

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: fostered

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Problem-solving: assessed

- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed

- **Personal Competencies**
  - Creative Thinking: fostered
  - Critical Thinking: fostered

### Hydrology and Water Cycle

#### Number Title Type ECTS Hours Lecturers

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<tr>
<th>Number</th>
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<td>701-1251-00L</td>
<td>Land-Climate Dynamics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. I. Seneviratne, R. Padron Flasher, P. Sieber</td>
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<td>Powerpoint slides will be made available</td>
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<td></td>
<td>Prerequisites: Introductory lectures in atmospheric and climate science</td>
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<td>Atmospheric physics -&gt; <a href="http://www.vvz.ethz.ch/Vorlesungsverzeichnis/lerneinheitPre.do?lerneinheitId=112225&amp;semkez=2017S&amp;lang=en">link</a> and/or</td>
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<td>Climate systems -&gt; <a href="http://www.vvz.ethz.ch/Vorlesungsverzeichnis/lerneinheitPre.do?lerneinheitId=112972&amp;semkez=2017S&amp;lang=en">link</a></td>
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<tr>
<td>701-1253-00L</td>
<td>Analysis of Climate and Weather Data</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>F. Isotta, R. Jnglin Wills, to be announced</td>
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<td>An introduction to methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of predictions, principal component analysis. Course goals: Participants understand the theoretical concepts and purpose of methods, can apply them independently, and know how to interpret results professionally.</td>
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<td>Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.</td>
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<td>The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.</td>
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<td>Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis, detection and attribution.</td>
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<td>The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.</td>
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<td>R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.</td>
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<td>Documentation and supporting material:</td>
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<tr>
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<td>- slides used during the lecture</td>
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<td>- exercise sets and solutions</td>
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<td>- R-packages with software and example datasets for workshop sessions</td>
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<td>All material is made available via the lecture web-page.</td>
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<td>For complementary reading:</td>
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<td>Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.</td>
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</tbody>
</table>
Analytical Competencies

Fostered

Concepts and Theories

Assessed

Techniques and Technologies

Assessed

Method-specific Competencies

Analytical Competencies

Assessed

Problem-solving

Assessed

Social Competencies

Communication

Fostered

Cooperation and Teamwork

Fostered

Personal Competencies

Adaptability and Flexibility

Fostered

Creative Thinking

Fostered

Critical Thinking

Assessed

Subject-specific Competencies

Watershed Modelling

A practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Main learning objective: Describe the main elements and processes and their interlinkages of the water cycle in mountain catchments and analyze their characteristics and changes.

Objective 1: Identify and describe the important components of the water cycle and their influencing factors and discuss how changes in these influencing factors may affect different parts of the hydrological cycle.

Objective 2: Analyse, visualize, and interpret climate and hydrological time series data.

Objective 3: Explain how hydrological data are collected, how hydrological models work, how they are calibrated, and how they are evaluated.

Streams are integrated monitors of the health and functioning of their surrounding landscapes. Streams integrate the fluxes of water, solutes, and sediment from their contributing catchment area; thus they reflect the spatially integrated hydrological, ecophysiological, biogeochemical, and geomorphological processes in the surrounding landscape. At a practical level, there is a significant public interest in managing upland landscapes to provide a reliable supply of high-quality surface water and to minimize the risk of catastrophic flooding and debris flows, but the scientific background for such management advice is still evolving.

Using a combination of lectures, field exercises, and data analysis, we explore the processes controlling the delivery of water, solutes, and sediment to streams, and how these processes are affected by changes in land cover, land use, and climate. We review the connections between process understanding and predictive modeling in these complex environmental systems. Practical problems to be considered include the effects of land use and climate on streamflow and water quality, illustrated with data from experimental watersheds in North America and Europe.

Lecture notes

Handouts will be available through moodle.

Literature

Recommended and required reading will be specified at the first class session (with possible modifications as the semester proceeds).

Competencies

Subject-specific Competencies

Concepts and Theories

Assessed

Techniques and Technologies

Assessed

Method-specific Competencies

Analytical Competencies

Assessed

Problem-solving

Assessed

Social Competencies

Communication

Fostered

Cooperation and Teamwork

Fostered

Personal Competencies

Adaptability and Flexibility

Fostered

Creative Thinking

Fostered

Critical Thinking

Assessed

Self-awareness and Self-reflection

Fostered

Watershed Modelling

W 5 credits 3G

M. Brunner, K. Meusburger Di Bella

Boundary Layer Meteorology

Z 4 credits 3G

M. Rotach, P. Calianca
The Planetary Boundary Layer (PBL) constitutes the lower part of the atmosphere, is characterized by turbulent mixing and ensures the exchange of energy, mass and momentum between the Earth’s surface and the atmosphere. The course provides the theoretical background for understanding the structure and dynamics of the PBL. Idealized concepts are reviewed and contrasted to real world applications.

Students are able to:
- Name the basic approaches needed to describe planetary boundary layer flows and associated turbulent exchange processes.
- Apply these concepts to answer comprehension questions and solve simple problems related to the structure and dynamics of the PBL.
- Independently judge the applicability of learned concepts and tools to real-world situations.

At the end of this course, participants should:
- Introduction
- PBL structure and stability
- Turbulence and turbulent transport
- Scaling and similarity theory
- Spectral characteristics
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Rough surfaces and the roughness sublayer
- Complex terrain

Contents:
The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change.


Prerequisites / notice
Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Competencies
Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
Method-specific Competencies: Analytical Competencies, Decision-making, Problem-solving
Personal Competencies: Creative Thinking

Eelectives

Climate Processes and Feedbacks

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1257-00L</td>
<td>European Climate Change</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>E. Fischer, J. Rajczak, S. C. Scherrer</td>
</tr>
</tbody>
</table>

Abstract
The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:
- observational datasets, observation and detection of climate change;
- underlying physical processes and feedbacks;
- numerical and statistical approaches;
- currently available projections.

Objective
At the end of this course, participants should:
- understand the key physical processes shaping climate change in Europe;
- know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
- be familiar with relevant observational and modeling data sets;
- be able to tackle simple climate change questions using available data sets.

Content
Contents:
- global context
- observational data sets, analysis of climate trends and climate variability in Europe
- global and regional climate modeling
- statistical downscaling
- key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects

Lecture notes
Slides and lecture notes will be made available at http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html

Prerequisites / notice
Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

Atmospheric Composition and Cycles

Climate History and Palaeoclimatology

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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4041-00L</td>
<td>Sedimentology I: Physical Processes and Sedimentary Systems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>V. Picotti</td>
</tr>
</tbody>
</table>

Abstract
Sediments preserved a record of past landscapes. This course focuses on understanding the processes that modify sedimentary landscapes with time and how we can read this changes in the sedimentary record.

Objective
The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change. They discuss the advantages and pitfalls of the method and look beyond. In particular we pay attention to introducing the importance of considering entire sediment routing systems and understanding their functioning.

Content
Details on the program will be handed out during the first lecture.

Literature
The sedimentary record of sea-level change
Angela Coe, the Open University.
Cambridge University Press

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.

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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>651-4043-00L</td>
<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
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</tbody>
</table>

Prerequisite: Successful completion of the MSc-course "Sedimentology I" (651-4041-00L).
Abstract
The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

Objective
- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonate systems
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and coral growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

Content
- Carbonates: chemistry, mineralogy, biology
- Carbonate sedimentation from the shelf to the deep sea
- Carbonate facies
- Cool-water and warm-water carbonates
- Organic-carbon and black shales
- C-cycle, carbonates, Corg : CO2 sources and sinks
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- Marine sediments through geological time
- Carbonates and evaporites
- Lacustrine carbonates
- Economic aspects of limestone

Lecture notes
We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.

651-4049-00L
Conceptual and Quantitative Methods in Geochemistry

| W       | 3 credits | 2G | G. De Souza, B. J. Peters, J-C. Storck |

Abstract
This course will introduce some of the main quantitative methods available for the quantitative treatment of geochemical data, as well as the main modelling tools. Emphasis will both be on conceptual understanding of these methods as well as on their practical application, using key software packages to analyse real geochemical datasets.

Objective
Development of a basic knowledge and understanding of the main tools available for the quantitative analysis of geochemical data.

Content
The following approaches will be discussed in detail: major and trace element modelling of magmas, with application to igneous systems; methods and statistics for calculation of isochrons and model ages; reservoir dynamics and modelling of ocean (biogeo)chemistry.

A special emphasis will be put on dealing with geochemical problems through modeling. Where relevant, software packages will be introduced and applied to real geochemical data.

Lecture notes
Slides of lectures will be available.

Prerequisites / notice
Pre-requisite: Geochemie I and II

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed
Social Competencies
Communication fostered
Personal Competencies
Creative Thinking fostered

651-4901-00L
Quaternary Dating Methods

| W       | 2 credits | 1G | I. Hajdas, M. Christl |

Abstract
Reconstruction of time scales is critical for all Quaternary studies in Geology and Archeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.

Objective
Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

At the end of the course, students will:
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. choose which dating method (or combination of methods) suits a certain field problem.
3. critically read and evaluate the application of dating methods in scientific publications.

Content
1. Introduction: Isotopes and decay
2. Radiocarbon dating: principles and applications
3. AMS technique and its application in Quaternary geochronology
4. U-series disequilibrium dating
5. Luminescence dating
6. Introduction to incremental: varve counting, dendrochronology, and ice cores chronologies
7. Dating anthropogenic records

Prerequisites / notice
Visit to radiocarbon lab, cosmogenic nuclide lab, and accelerator (AMS) facility.

Required: attending the lecture, visiting laboratories, handing back solutions for problem sets, short presentations or written report

Optional (individual): 1-5 days of hands-on radiocarbon dating at the 14C lab, ETH Hoenggerberg

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered
Method-specific Competencies
Analytical Competencies fostered
Problem-solving fostered
Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Personal Competencies
Critical Thinking fostered
### Environmental Soil Physics/Vadose Zone Hydrology

**Number**: 701-0535-00L  
**Title**: Environmental Soil Physics/Vadose Zone Hydrology  
**Type**: W  
**ECTS**: 3 credits  
**Hours**: 2V+1U  
**Lecturers**: A. Carminati, P. U. Lehmann Grunder  

#### Abstract

The course provides theoretical and practical foundations for understanding and characterizing physical soil properties and processes and their relevance for terrestrial ecosystems, plant growth, hydrological processes and atmospheric-land gas exchange, across all relevant scales.

#### Objective

Students are able to:

- Characterize the different soils based on their key textural and structural properties.
- Simulate and predict soil water retention and flow under varying environmental conditions and understand the key driving forces (capillarity, gravity, friction) and related water properties (surface tension and viscosity).
- Predict soil hydraulic properties for varying soil textural classes.
- Predict solute transport in soils for varying environmental conditions.
- Predict energy balance and temperature dynamics in soils.
- Predict conditions for plant water stress.
- Estimate the impact of soil properties on the hydrological cycle and on plant growth.

#### Content

**INTRODUCTION**  
Week 1 (September 18)
Presentation of the role of soil physics in environmental sciences and terrestrial ecosystems: soils in the water cycle; soils and vegetation; soils and solute transport. Survey on students' interests and expectations. Presentation of course structure and learning objectives.

**BASIC SOIL PROPERTIES**  
Week 2 (September 25) and Week 3 (October 02)
soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density  
Pore scale consideration (water in a single pore), pore sizes and shapes; surface tension; Young-Laplace equation; capillary rise; contact angle  
Friction and laminar flow; Hagen-Poiseuille's law; Washburn equation; numerical lab (REPORT 1)

**SOIL HYDRAULIC PROPERTIES**  
Week 4 (October 09) and Week 5 (October 16)
Soil water content and soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point  
Soil water characteristics and pore size distribution  
Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts; effective conductivity; unsaturated hydraulic conductivity; Buckingham law.  
Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications

**TOOLBOX – MEASUREMENTS AND MODELING**  
Week 6 (October 23) and Week 7 (October 30)
Measuring soil hydraulic properties, fitting and interpretation; Lab tour - demonstration of soil physical methods; lecture on HYPROP method; report on Hyprop data (REPORT 2)  
Modelling unsaturated water flow based on Richards equation - Using Hydrus1D for simulation of unsaturated flow; simulating HYPROP measurements (REPORT 3)

**SOIL IN THE WATER CYCLE**  
Week 8 (November 06) – Week 9 (November 13)
Water infiltration - steady state solutions for infiltration; approximate solutions to infiltration (Green-Ampt, Philip); infiltration rate and ponding; outlook to preferential flow  
Water evaporation - Energy balance and land atmosphere interactions - potential and actual evaporation, evaporation stages;

**SOIL PLANT INTERACTIONS**  
Week 10 (November 20) Week 11 (November 27)
Root water uptake and transpiration – Theory and mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance.  
Modelling root water uptake and transpiration; analytical approaches and modeling using Hydrus (REPORT 4)

**SOLUTE TRANSPORT**  
Week 12 (December 04) Week 13 (December 11)
Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application  
Transport of reactive substances, preferential flow, simulations with Hydrus

**CLOSURE**  
Week 14 (December 18)
Summary, course synthesis, connections between the different topics, questions, exam preparation

### Literature

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

### Competencies

#### Subject-specific Competencies

- Concepts and Theories  
- Techniques and Technologies

#### Method-specific Competencies

- Analytical Competencies  
- Decision-making  
- Problem-solving  
- Project Management

#### Social Competencies

- Communication  
- Cooperation and Teamwork  
- Leadership and Responsibility

#### Personal Competencies

- Adaptability and Flexibility  
- Creative Thinking  
- Critical Thinking  
- Integrity and Work Ethics  
- Self-awareness and Self-reflection  
- Self-direction and Self-management

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**River Basin Erosion**

**Number**: 102-0287-00L  
**Title**: River Basin Erosion  
**Type**: W  
**ECTS**: 3 credits  
**Hours**: 2G  
**Lecturers**: P. Molnar
Abstract
The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

Objective
The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-riparian gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Content
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-riparian gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Lecture notes
There is no script.

Literature
The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice
Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).
Atmospheric passive and active remote sensing is connected with a large number of applications including: atmospheric composition, Earth-atmosphere radiative balance, atmospheric and weather prediction model assimilation, agriculture, energy and health related applications and many others.

The proposed lesson is divided in three sections including exercises:
- Fundamentals of remote sensing
- Sensors (surface based and satellites) and retrieval methods
- Applications

The first aim of the lecture is to provide an in-depth understand of the physical aspects and basic laws on the fundamentals of remote sensing to the students. The lectures will provide a basic to intermediate understanding of radiative transfer of electromagnetic radiation through the atmosphere, covering the spectrum from UV to thermal. Examples of atmospheric components that will be addressed are: ozone, aerosols, greenhouse gases, clouds, water vapor.

In addition, measuring sensors used from the surface or from satellites and the relevant retrieval methods based on passive and active remote sensing of atmospheric composition will be presented (e.g. Spectroradiometers, filter radiometers, Lidars and others).

Finally, we aim to demonstrate a series of diverse remote sensing applications, including atmospheric composition measurements and retrievals from surface- and satellite-based instruments, including calibration and validation aspects. The exercises will be embedded in the overall course lectures to provide hands-on experience with the measurements and retrieval methods conducting measurements and organizing small field experiments. Also with the use of atmospheric datasets available from specific instruments (e.g. satellite sensors) and networks (e.g. AERONET, GAWPPFR).

More specific the course include:
- 3 introductory courses on climate variables, sensors, solar measurements and radiative transfer basics
- 7 courses including remote sensing techniques on solar UV measurements, total column ozone, trace gases, greenhouse gases, aerosols, cloud retrievals and lidar active remote sensing.

3 exercises:
- Conducting sun photometric measurements in the field and retrieve aerosol optical depth, including a visit in Davos, World Calibration Center
- Exploring ground and satellite based solar UV, Ozone and aerosol measurements
- Using radiative transfer modeling tools

Finally, students are involved on presenting scientific literature on subjects they are interested in.
All exercises are conducted in student-forming teams

Lecture notes
Lecture slides will be provided via Moodle before every lecture.

Prerequisites / notice
none

Competencies

Subject-specific Competencies
- Concepts and Theories
  - assessed
- Techniques and Technologies
  - assessed

Method-specific Competencies
- Analytical Competencies
  - Decision-making
  - assessed
- Media and Digital Technologies
  - fostered
- Problem-solving
  - assessed
- Project Management
  - fostered

Social Competencies
- Communication
  - assessed
- Cooperation and Teamwork
  - assessed
- Customer Orientation
  - fostered
- Leadership and Responsibility
  - fostered
- Self-presentation and Social Influence
  - fostered
- Sensitivity to Diversity
  - fostered
- Negotiation
  - fostered

Personal Competencies
- Adaptability and Flexibility
  - fostered
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - assessed
- Self-awareness and Self-reflection
  - fostered
- Self-direction and Self-management
  - fostered

701-1271-00L Statistical Learning for Atmospheric and Climate Science
W 3 credits 2G L. Gudmundsson, D. Nerini

Abstract
This course offers a systematic introduction to statistical and machine learning methods with focus on applications in atmospheric and climate science. Focus is on the theoretical and mathematical basis of supervised statistical learning (advanced regression, nonparametric methods) and their application in practice with hands-on exercises.

Objective
Students:
- Understand the theoretical basis of machine learning
- Are familiar with overarching concepts such as bias-variance trade-off, cost-functions, hyper parameters, cross-validation
- Have good command of the theoretical basis of selected machine learning tools
- Are able to select the appropriate statistical learning tools to tackle atmospheric and climate research problems
- Can apply methods of statistical learning in atmospheric and climate research
- Data in atmospheric and climate research (data types, observations, models)
- Exploring properties of atmospheric and climate data (data in space and time, multivariate data)
- Concepts of supervised learning (bias variance trade-off, overfitting, cross-validation)
- Advanced linear regression (multiple linear regression, regularization)
- Non-linear regression (local linear regression, regression trees, gradient boosting, random forests, neural networks)
- Bootstrapping
- Keynote speakers showcasing recent topics in statistical learning and high-level applications for atmospheric and climate research
Analytical Competencies fostered

Environmental Systems Data Science: Machine Learning

This course gives an introduction into Accelerator Mass Spectrometry (AMS), the most sensitive method for measuring long-lived radionuclides in natural samples.

Prerequisites / notice

- Knowledge of introductory statistics
- Overview on the climate system
- Basic experience in a programming language

Course is limited to 30 participants.

Exercises will be in the R for most of the sessions and in Python for deep learning.

Competencies

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<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
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<td>Concepts and Theories</td>
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701-3001-00L Environmental Systems Data Science: Data Processing

Abstract

Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective

The students are able to:
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content

- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice

- Basic experience in a programming language
- Overview on the climate system
- Knowledge of introductory statistics

701-3003-00L Environmental Systems Data Science: Machine Learning

Abstract

Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective

The students are able to:
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to training and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content

- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature

Building on existing data science resources

Prerequisites / notice

- Math IV, VI (Statistics); R, Python; ESDS l

402-0621-00L Introduction to Accelerator Mass Spectrometry

Abstract

This course gives an introduction into Accelerator Mass Spectrometry (AMS), the most sensitive method for measuring long-lived radionuclides in natural samples.

Objective

Students learn the basic concepts of Accelerator Mass Spectrometry. Based on the underlying physics of ion matter interaction they learn the measurement methods and interpretations of the results for most of the important AMS radionuclides, e.g. radiocarbon (14C), the cosmogenic radionuclides 10Be, 26Al, 36Cl, and anthropogenic nuclides 129I, 236U and other actinides.

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Introduction into the physics of ion matter interaction: ion stopping, ion scattering and charge exchange.

Ion optics and ion acceleration.

Mass separation, molecular destruction and isobar separation.

Ion detection and identification.

The measurement methods for all the important radionuclides and the interpretation of their results are discussed on a few examples from the application:

- $^{14}C$ – radiocarbon dating and environmental studies
- $^{10}Be$, $^{26}Al$, $^{36}Cl$ – cosmogenic dating and ice core research
- $^{129}I$, $^{236}U$, actinides – anthropogenic tracers in the environment
- $^{14}C$, $^{41}Ca$ – biomedical studies
- $^{60}Fe$, $^{244}Pu$ – astrophysics

Alternative methods: ICP-MS, RIMS, ATTA

A visit to the Tandem accelerator and AMS facilities at ETH Hönggerberg is organized as part of lectures and exercises.

Lecture notes
Lecture notes will be distributed in pdf

**Numerical Modelling in Fortran**

- **Course Code**: 651-4273-00L Numerical Modelling in Fortran
- **ECTS**: 3 credits
- **Lecturers**: P. Tackley

**Abstract**
This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

**Objective**
Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

**Lecture notes**
See [http://jupiter.ethz.ch/~pjt/FORTRAN/FortranClass.html](http://jupiter.ethz.ch/~pjt/FORTRAN/FortranClass.html)

**Numerical Modelling in Fortran (Project)**

- **Course Code**: 651-4273-01L Numerical Modelling in Fortran (Project)
- **ECTS**: 1 credit
- **Prerequisite**: 651-4273-00L Numerical Modelling in Fortran
- **Lecturers**: P. Tackley

**Abstract**
This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

**Objective**
Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

**Content**
The project consists of writing a Fortran program to solve a problem agreed upon between the instructor and student; the topic is often related to (and helps to advance) the student's Masters or PhD research. The project is typically started towards the end of the end of the main Fortran class when the student has acquired sufficient programming skills, and is due by the end of Semesterprüfung week.

**Lecture notes**
See [http://jupiter.ethz.ch/~pjt/FORTRAN/FortranProject.html](http://jupiter.ethz.ch/~pjt/FORTRAN/FortranProject.html)

**Major in Biogeochemistry and Pollutant Dynamics**

**Biogeochemical Processes**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1313-00L</td>
<td>Isotopes and Biomarkers in Biogeochemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>C. Schubert, N. Casacuberta Arola, R. Kipfer</td>
</tr>
<tr>
<td>701-1315-00L</td>
<td>Biogeochemistry of Trace Elements</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Voegelin, D. Janssen, L. Winkel</td>
</tr>
</tbody>
</table>
Climate Change Mitigation: Carbon Dioxide Removal

The lecture 701-1315-00L Biogeochemistry of Trace Elements is a prerequisite for attending the laboratory course 701-1331-00L Trace Elements Laboratory, or students must be concurrently enrolled in 701-1315-00L Biogeochemistry of Trace Elements in the same semester.

Applications

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1346-00L</td>
<td>Climate Change Mitigation: Carbon Dioxide Removal</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>N. Gruber, C. Brunner</td>
</tr>
<tr>
<td>701-1351-00L</td>
<td>Anthropogenic Particles in the Environment</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>B. Nowack, T. Bucheli, D. Mitrano</td>
</tr>
<tr>
<td>101-0339-00L</td>
<td>Environmental Geotechnics – Polluted Sites and Waste Disposal</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Plötze</td>
</tr>
</tbody>
</table>

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Method-specific Competencies
- Life cycle assessment
- Environmental risk assessment
- Uptake and toxicity of particles
- Fate in technical systems: water treatment, waste incineration
- Fate in the environment: water, soil, air
- Fate in technical systems: water treatment, waste incineration
- Uptake and toxicity of particles
- Environmental risk assessment
- Life cycle assessment

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Personal Competencies
- Decision-making
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Project Management
- Communication
- Negotiation

Exams: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

Prerequisites / notice
- Students are expected to be familiar with the basic concepts of aquatic and soil chemistry covered in the respective classes at the bachelor level (soil mineralogy, soil organic matter, acid-base and redox reactions, complexation and sorption reactions, precipitation/dissolution reactions, thermodynamics, kinetics, carbonate buffer system).
- The lecture 701-1315-00L Biogeochemistry of Trace Elements is a prerequisite for attending the laboratory course 701-1331-00L Trace Elements Laboratory, or students must be concurrently enrolled in 701-1315-00L Biogeochemistry of Trace Elements in the same semester.

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This lecture course consists of lectures with exercises and case studies.

- An overview of the principles of environmental protection in waste management and how this is applied in legislation.
- An overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes controlling mobility of heavy metals and organic compounds
- Introduction to contaminant transport in porous adsorbing media
- Design and function of engineered barriers. Clay as a barrier.
- Polluted site remediation: Site investigation, assessment, and remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

### Prerequisites / Notice

**Competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Techniques and Technologies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>fostered</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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</table>

### Methods and Tools: Lab Courses

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1331-00L</td>
<td>Biogeochemistry of Trace Elements Laboratory</td>
<td>W</td>
<td>3 credits</td>
<td>4P</td>
<td>P. Lefebvre, A. Grigg, M. Le Bars</td>
</tr>
</tbody>
</table>

**Abstract**
The course offers a practical introduction into the investigation of the biogeochemistry of trace elements. Laboratory experiments are performed to study a selected environmental process. Advanced techniques for the analysis of total element contents and element speciation are used. The experimental findings are interpreted and discussed in their environmental context.

**Objective**
The objective of this course is to offer students a practical introduction into the investigation of the biogeochemistry of trace elements. During the course, students will become familiar with some of the key experimental approaches typically used in the investigation of the biogeochemistry of trace elements in the laboratory. In addition, students will learn to use different advanced analytical techniques to measure the total content and the speciation of trace elements in both liquid and solid samples. The students will interpret and discuss their experimental findings in the context of the studied environmental system.

**Content**
Laboratory experiments are designed and performed to study the interplay of various biogeochemical processes in a specific environmental system. Moreover, the effect of these processes on the biogeochemical cycling of trace elements in the environment will be considered. Advanced techniques for the analysis of total element contents and element speciation are used. The experimental findings are interpreted and discussed in the context of the studied environmental system.

**Lecture notes**
Selected handouts will be distributed during the course.

**Literature**
All necessary literature will be uploaded to moodle during the course.

**Prerequisites / Notice**
Pre- or corequisite: Lecture "Biogeochemistry of Trace Elements".

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Techniques and Technologies</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>fostered</td>
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<tr>
<td>701-1333-00L</td>
<td>Isotopes and Biomarkers in Biogeochemistry Laboratory</td>
<td>W</td>
<td>3 credits</td>
<td>4P</td>
<td>C. Schubert, R. Kipfer</td>
</tr>
</tbody>
</table>

**Abstract**
This course will illustrate how different tracers and isotopes are used in natural systems. Here especially the processes (transformation, timescales) that take place and can be revealed by tracers/isotopes will be demonstrated.

**Objective**
Students know how to use tracers/isotopes to investigate/understand ecosystems
They will understand the methods and techniques related to tracer/isotope work
Have a feeling for timescales on which natural processes occur
Students will be able to apply different sampling techniques in aquatic sciences

**Content**
Basics:
O,H isotopes as tracers for mixing in aquatic systems
Carbon isotopes as tracer for methane oxidation
210Pb, 137Cs as a tracer for sedimentation rate/mixing
SF6, Neon, He as tracers for exchange processes at the air/water interface
Case assessment:
Sampling of a Swiss lake (Rotsee)
Sampling techniques for different elements
Sample preparation for different techniques
Measurements at isotope mass spectrometer/gamma counter
Interpretation of results from the special sampling campaign and in a broader context

**Prerequisites / Notice**
Sampling will take place in Rotsee (Lucerne). We will have 3 laboratory days at Eawag Kastanienbaum, 1 laboratory day at Eawag Duebendorf, and 2 days of preparation of a presentation and the presentation itself at ETH (Center). The presentation will be evaluated and is necessary to pass the class.

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1337-00L</td>
<td>Forest Soils in a Changing Environment</td>
<td>W</td>
<td>3 credits</td>
<td>4P</td>
<td>F. Hagedorn, P. F. Schleppi</td>
</tr>
</tbody>
</table>

**Abstract**
The students are measuring carbon and nutrient fluxes in forest soils under a changing climate and land-use. In laboratory and field experiments, they are manipulating climatic conditions (temperature, drought) and quantify the response of C and N fluxes in soils, and plant-soil interactions. The results will be interpreted and discussed in the context of changes in climate and land-use.
Objective

The students get first-hand experience with field and laboratory methods to measure carbon and nutrient fluxes and the application of stable isotope techniques. They shall learn about physico-chemical properties of Swiss forest soils, how these properties determine the ecological functions of soils and how soils respond to changes in climate and land-use. Finally the students shall interpret, discuss and present their experimental data.

Content

1. Introduction to the ecological functions of Swiss forest soils
2. Measurement of soil CO2 efflux, carbon and nutrient leaching in forest and grassland soils
3. Sampling and preparation of litter and soil samples from selected soil profiles under different land-uses
4. Setting-up laboratory experiments in microcosms. Measurement of soil respiration and leaching of carbon, nutrients and/or contaminants in climate chambers under different environmental conditions.
5. Analyses of litter, soil, and soil water for selected physical and chemical properties.
7. Interpretation and final presentation of data

Lecture notes

A manual will be distributed during the course.

Literature

Selected publications will be distributed during the course.

701-1339-00L Soil Solids Laboratory

Abstract

The main part of the course is the investigation of real samples of soils/sediments in the lab working in groups. A brief theoretical introduction into the overall principle and the meaning of physical, mineralogical and chemical parameters of soils and sediments and into each analytical method for their investigation will be given in advance.

Objective

Upon successful completion of this course students are able to:
- describe structural, mineralogical and chemical properties of the inorganic solid part of soils and sediments,
- propose and apply different advanced methods and techniques to measure these properties,
- critically assess the data and explain the relationships between them,
- communicate the results in a scientific report.

The competencies of process understanding, system understanding, concept development, and measurement methods are taught and assessed.

Content

Basic introduction to mineralogy and texture of soils
Analytical techniques
Practical exercises in sample preparation
Measurement and evaluation of the data:
- physical parameters (grain size distribution, surface, densities, porosity, (micro)structur)
- mineralogical/geochemical parameters (quantitative mineralogical composition, thermal analysis, cation exchange etc.)

Lecture notes

Selected handouts will be distributed during the course.

Literature


Prerequisites / notice

In order to allow for effective lab work not more than 12 students can join the course.

701-1673-00L Environmental Measurement Laboratory

Abstract

Measurements are the sole judge of scientific truth and provide access to unpredictable information, enabling the characterization and monitoring of complex terrestrial systems. Based on lectures and field- and laboratory training, the students learn to apply modern methods to determine forest inventory parameters and to measure subsurface properties and processes.

Objective

The students will be able to:
- explain measurement principles that are used for characterization of landscapes and terrestrial systems
- select appropriate measurement methods and sampling design to quantify key variables and processes above ground and in the subsurface
- deploy sensors in the field
- interpret collected laboratory and field data and report main conclusions deduced from measurements

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Content

Week 1: Plant-Soil interactions – short introduction before sensor demonstration and installation in forest lab; Scholander pressure bomb (suction in leaves); LiCOR soil chamber

Weeks 2 to 6 - Experimental Methods for Soil Health Assessment

Week 2: Lecture on soil health and soil indicators; defining measurable soil health indicators for case studies for different soil threats and climate regions

Week 3: Short lecture on sampling, sensors and data logging; preparing sensors and data loggers in the lab; measurements on water content and temperature in the lab

Week 4: Short introduction on field installation; sensor installation at field site Hönggerberg

Week 5: Lecture on geophysical methods on subsurface characterization: basic principles of ERT, GPR, and EM; planning of field experiment to assess soil health

Week 6: Short introduction on data analysis; field sampling and conducting field experiment to assess soil health

Week 7: Analysis of experimental data and soil health assessment; poster presentation and discussion

Week 8: Lecture on plant soil relationship; connecting information below and above ground – data analysis

Weeks 9 and 10: Forest characterization/ inventory: Principles of LiDAR; structures and features of the tree crowns, size/volume of the leaf area tree positions and diameters at breast height

Weeks 11 and 12: Eddy covariance methods -Principles for field measurement of water vapor, carbon dioxide, and energy exchange between terrestrial surfaces and the atmosphere; Analysis of measured time series to determine evaporation rate and CO2-fluxes

Week 13: Swiss Soil Monitoring networks – Monitoring of soil water content and potential; climate change and droughts

Week 14: Global data – Global modeling and data interpretation; SoilGrids and OpenLandMap; exercises on Budyko analysis

Literature
Lecture material will be online for registered students using moodle

Prerequisites / notice
The details of the schedule will be optimized based on the number of students; some blocks of the course will be offered as well to students of Environmental Engineering

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Decision-making fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered

Personal Competencies
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered

Seminar and Semester Paper

701-1303-00L Term Paper 1: Writing
Prerequisite: Term Paper 1: Writing (701-1303-00L).

701-1302-00L Term Paper 2: Seminar
Prerequisite: Term Paper 1: Writing (701-1303-00L).

Number Title Type ECTS Hours Lecturers

Abstract
The ability to critically evaluate original (scientific) literature and to summarise the information in a succinct manner is an important skill for any student. This course aims to practice this ability, requiring each student to write a term paper of scientific quality on a topic of relevance for research in the areas of biogeochemistry and pollutant dynamics.

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies fostered

Social Competencies
Communication assessed

Personal Competencies
Creative Thinking fostered
Critical Thinking assessed

Abstract
This class is the 2nd part of a series and participation is conditional on the successful completion of "Term Paper 1: Writing". The results from the term paper written during the previous term are presented to the other students and advisors and discussed with the audience.

Objective
The goal of the term paper seminars is to train the student's ability to communicate (scientific) results to a wider audience and the ability to respond to questions and comments.

Content
Each student presents the results of their term paper to fellow students and advisors and responds to questions and comments from the audience.

Lecture notes
Guidelines and supplementary material are distributed on the Moodle platform.

Prerequisites / notice
Guidelines and supplementary material are distributed on the Moodle platform.

To obtain the credits, it is mandatory to attend at least 60% of all seminar dates offered in the fall and spring semester. Active participation in discussion and feedback rounds is expected.
The goal of the term paper is to train the student's ability to critically evaluate scientific literature and to summarise the findings concisely in a paper addressing a research question.

At the end of the course, students will be able to:
- narrow down a research question.
- identify relevant literature to address the research question.
- concisely summarise and critically evaluate their findings.
- formulate key outstanding questions.

Each student is expected to write a paper with a length of approximately 15-20 pages. The students can choose from a list of topics prepared by the tutors, but the final topic will be determined based on a balance of choice and availability. The students will be guided and advised by their tutors throughout the term.

The paper itself should contain the following elements:
- Motivation and context of the given topic (25%)
- Concise presentation and critical evaluation of the state of the science (50%)
- Identification of open questions and perhaps opportunities for further research (20%)
- Declaration and reflection on the use of technical tools (5%)

In addition, the accurate use of citations, attribution of ideas, and the judicious use of figures, tables, equations and references are critical components of a successful paper. Specialised knowledge is not expected, nor required; neither is new research.

Each student submits a term paper that will be reviewed by one fellow student and one faculty. The submission of the term paper and a written review of another student's term paper are a condition for obtaining the credit points.

The term paper course is primarily aimed at master students majoring in biogeochemistry & pollutant dynamics and ISTP students with a solid background in natural sciences and a strong interest in biogeochemistry & pollutant dynamics.

Each student submits a term paper that will be reviewed by one fellow student and one faculty. The submission of the term paper and a written review of another student's term paper are a condition for obtaining the credit points.

There is no final exam. The grade is assigned based on the quality of the term paper and the submitted review as well as on the presentation in the following term.

Results from the term paper will be presented to fellow students and involved faculty in the following semester ("Term Paper 2: Seminar").

The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding.

The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

The students are able to
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding.
Content
• The data science workflow
• Data preparation for running and validating machine learning models
• Get to know machine learning approaches including regression, random forest and neural network
• Model complexity and hyperparameters
• Model parameterization and loss
• Model evaluations and uncertainty
• Deep learning with convolutions

Literature
Building on existing data science resources

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I

Major in Ecology and Evolution

A. Fundamentals

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0328-00L</td>
<td>Advanced Ecological Processes</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>J. Hille Ris Lambers</td>
</tr>
</tbody>
</table>

Abstract
This course presents a broad overview of the key processes structuring ecological populations and communities, with a particular focus on understanding and managing global change impacts.

Objective
COURSE GOALS
In this course, students will develop an integrated knowledge of how ecological theory can help us understand and manage ecological responses to global change. Specifically, the course goals are to:

- Introduce students to the major ecological processes that together shape the composition and abundance of species within ecological communities.
- Provide insight to students on the ecological impacts of anthropogenic change, and how an understanding of ecological processes can help us predict these ecological impacts and design conservation / restoration actions to mitigate their negative impacts.
- Teach students to critically summarize and analyze primary ecological literature, understanding how ecological studies contribute to our knowledge, how to critically evaluate their strengths and weaknesses, and practice designing follow up studies.

LEARNING OBJECTIVES
The learning objectives follow from the course goals. After attending this course, students should be able to:

- Describe key processes affecting the size of populations and abundance of species within ecological communities.
- Critically evaluate evidence and conclusions presented in primary ecological literature based on your understanding of these ecological processes.
- Apply knowledge of ecological processes to make predictions about the major responses of ecological communities to anthropogenic perturbations.

Content
We will explore how ecological theories can provide insight into the effects of anthropogenic change as well as guide management to undo undesired impacts. Collectively, this requires us to focus on classic problems in ecology (for examples, competitive coexistence, top-down impacts of predators, diversity-ecosystem function relationships, the role of dispersal in spread).

The course is taught in a flipped format. Generally (with the exception of a few weeks), there will be online materials for students to watch or read during the first hour of class (lecture videos, readings), and the class will meet in person for the second half of class. The in person portions of the class will have students participate in activities to learn the content, including paper discussions, groupwork, and presentations. Students are also required to submit a written assignment.

Competencies
Subject-specific Competencies
- Concepts and Theories: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Problem-solving: fostered

Social Competencies
- Communication: assessed

Personal Competencies
- Cooperation and Teamwork: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered

B. Concept Courses and Applications

Advanced Concept Classes

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
</tbody>
</table>

Abstract
Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

Objective
This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

Content
A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

Lecture notes
Publications and class notes can be downloaded from a web page announced during the lecture.

Literature
Papers will be assigned and downloaded from a web page announced during the lecture.
<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Conceptual and Theoretical</th>
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<tbody>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>fostered</td>
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<td>Critical Thinking</td>
<td>fostered</td>
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<td>Self-awareness and Self-reflection</td>
<td>fostered</td>
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<tr>
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<th>Course Title</th>
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<th>Type</th>
<th>Instructor(s)</th>
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<tr>
<td>701-1409-00L</td>
<td>Research Seminar: Ecological Genetics</td>
<td>W 2</td>
<td>1S</td>
<td>S. Fior</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>In this research seminar we will critically discuss recent publications on current topics in Ecological Genetics.</td>
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<td><strong>Objective</strong></td>
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<td>It is our aim that participants gain insight into current research topics and approaches in Ecological Genetics and learn to critically assess and appreciate scientific publications in this field.</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
<td>none</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
<td>will be distributed</td>
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<td><strong>Prerequisites / notice</strong></td>
<td>Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course.</td>
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<td>It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).</td>
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<tr>
<td>701-1471-00L</td>
<td>Ecological Parasitology</td>
<td>W 3</td>
<td>1V+1P</td>
<td>F. Feijen, J. Jokela, C. Vorburger</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>The course will not take place fall semester 2024.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>1. Identify common macroparasites in invertebrates.</td>
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<td>2. Understand ecological and evolutionary processes in host-parasite interactions.</td>
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<td>3. Conduct parasitological research</td>
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<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>Lectures:</td>
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<tr>
<td></td>
<td>1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).</td>
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<td>2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).</td>
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<td>3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).</td>
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<td></td>
<td>4. Ecology and evolution of parasitoids and their applications in biocontrol</td>
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<td></td>
<td>5. Human macroparasites (schistosomiasis, malaria).</td>
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<td><strong>Practical exercises:</strong></td>
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<td></td>
<td>1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).</td>
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<td>2. Examination of parasites in amphipods (identification and examination of effects on hosts).</td>
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<td></td>
<td>3. Examination of parasitoids of aphids.</td>
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<td><strong>Prerequisites / notice</strong></td>
<td>The three practicals will take place at the 03.10.2023, the 17.10.2023 and the 07.11.2023 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.</td>
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<tr>
<td>701-1676-01L</td>
<td>Genomics of Environmental Adaptation</td>
<td>W 2</td>
<td>3G</td>
<td>C. Rellstab, B. Dauphin, F. Gugerli</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This five-day winter school aims at teaching advanced Master students, PhD students and postdoctoral researchers on aspects of the genomics of environmental adaptation. It provides both theoretical background and hands-on exercises on major topics of contemporary environmental genomics such as signatures of selection, outlier analysis, genotype-environment associations, or GWAS.</td>
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### Objective
The genomics of environmental adaptation is an evolving scientific field of both basic and applied interest. Researchers make increasing use of diverse methodological approaches built on concepts from ecology, evolutionary biology and population genomics. This five-day winter school introduces students to some major concepts and methods of environmental genomics, i.e., (i) how the environment and adaptive genetic variation are related and (ii) how signatures of genomic adaptation can be detected in natural populations. The winter school focuses on current methods and hands-on exercises, emphasizing an understanding of the underlying concepts and a discussion of benefits, limitations and pitfalls of environmental genomics. It is specifically aimed at the needs of advanced Master students, PhD students and early postdoctoral researchers.

### Content
**Topics:**
1. Molecular markers and next generation sequencing techniques; neutral and adaptive genetic variation, genetic drift and genetic population structure.
2. Outlier analysis: concept, methodology and types of outlier analyses.
3. Environmental data: which environmental data are available and used to identify signatures of adaptation; data limitations; collinearity.
5. Genotypes and phenotypes: GWAS; follow-up analyses.

**Lecture notes**
- Hand-outs will be distributed.

**Literature**
The course requires 4 hours of preparatory reading of selected papers on the genomics of environmental adaptation. The papers will be distributed by e-mail.

**Prerequisites / notice**
Grading will be according to a written report (8-10 pages), in which students will have to design a complete study in environmental genomics, and according to student contributions during the course.

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- **Method-specific Competencies**
  - Analytical Competencies: fostered
  - Problem-solving: fostered
  - Project Management: fostered
- **Social Competencies**
  - Communication: fostered
  - Cooperation and Teamwork: fostered
- **Personal Competencies**
  - Creative Thinking: fostered
  - Critical Thinking: fostered

**701-1703-00L**
**Evolutionary Medicine for Infectious Diseases**
- **W 3 credits**
- **2G A. Hall**

**Abstract**
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

**Objective**
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

**Content**
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

**Prerequisites / notice**
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

**Competencies**
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- **Method-specific Competencies**
  - Analytical Competencies: fostered
  - Problem-solving: fostered
  - Project Management: fostered
- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: fostered
- **Personal Competencies**
  - Creative Thinking: fostered
  - Critical Thinking: assessed

**636-0017-00L**
**Computational Biology**
- **W 6 credits**
- **3G+2A T. Vaughan, C. Magnus, T. Stadler**

**Abstract**
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

**Objective**
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

**Data:** 02.07.2024 12:39  
**Autumn Semester 2024  
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The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GNAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylogeography, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.

Literature
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
* Yang, Z. 2006. Computational Molecular Evolution.
* Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). If you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

751-5101-00L Biogeochemistry and Sustainable Management

Abstract
This course focuses on the interactions between ecology, biogeochemistry and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems.

Objective
Students will analyse and understand the complex and interacting processes of ecology, biogeochemistry and management of agroecosystems. They will use their theoretical knowledge in two flipped classroom exercises, but also set up a small weather station and program a data logger to collect meteorological variables, analyze large meteorological and flux data sets, and evaluate the impacts of weather events and management practices on the ecosystem greenhouse gas exchange. Thus, students will expand their computational competences. Moreover, students will be able to coordinate and work successfully in small (interdisciplinary) teams.

Content
Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact of any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere-interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

Students will gain profound knowledge about biogeochemical cycles and greenhouse gas fluxes in managed grassland and/or cropland ecosystems as well as expand their computational competences. Responses of agroecosystems to the environment, i.e., to climate and weather events, but also to management will be studied. Two flipped classroom exercises include the assessment of an ecosystem disturbance and the experimental design of an own study. Dataloggers will be programmed, and a small weather station will be set up. Different meteorological and greenhouse gas flux data will be analysed (using R) and assessed in terms of production, greenhouse gas budgets, and carbon sequestration. Thus, students will learn how to collect, analyse and interpret data about the complex interactions of a coupled human-environmental system.

Students will work in groups (3-4 persons per group) with data from a small weather station (dedicated to the course), as well as data from the long-term measurement network Swiss FluxNet and from global databases. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

Lecture notes
Handouts will be available in moodle.

Prerequisites / notice
Prerequisites: Attendance of introductory courses in plant ecophysiology, ecology, and grassland or forest sciences. Knowledge of data analyses in R and statistics. Course will be taught in English.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management assessed
Social Competencies
Cooperation and Teamwork assessed
Personal Competencies
Critical Thinking assessed
Self-direction and Self-management assessed

Applications

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-1453-00L</td>
<td>Ecological Assessment and Evaluation</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>F. Knaus</td>
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</tbody>
</table>

Abstract
The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

Objective
Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

Lecture notes
Powerpoint slides are available on the moodle page. Additional documents are handed out as copies.

Literature
Basic literature and references are listed on the webpage.
Prerequisites / notice
The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group. Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

701-1613-01L Landscape Patterns and Processes

Abstract
This course introduces landscapes as socially perceived, spatially and temporally dynamic entities that are shaped by natural and societal factors. Concepts and qualitative and quantitative methods to study landscapes from an ecological and societal perspective are presented. The course consists of a mixture of theoretical lectures and exercises or practical sessions.

Objective
Students will learn:
- The use of spatial data and analyses for quantifying patterns and processes in landscapes
- Concepts and methods to quantify functional connectivity in landscapes and seascape.
- The use of remote sensing (satellites images, drones) to extract information about landscape structure and change, with a focus on land-use.
- The use of landscape genetics and its application to biodiversity conservation.
- To computationally optimize land-use planning problems.
- Concepts and methods in scenario-based land-use change modelling.
- Landscape ecological concepts and planning tools for management of urban landscapes.
- Concepts of social preference of landscapes and related measurement methods.
- how to design urban environments that foster health and well-being.
- The role of landscape features in influencing human well-being.
- Approaches of actively influencing attitudes and behavior toward landscapes as well as their scientific evaluation.

Content

Thematic topics
1. Ecological quantification of landscape patterns:
   - Landscape resources and green infrastructure (e.g., ecological conservation areas).
   - Landscape and seascape connectivity.
   - Landscape genetics and conservation applications.
   - Concepts of spatial quantitative methods: least cost paths, resistance surfaces, Circuitscape, land-use change models, various statistical methods.
   - Image processing from remote sensing from satellites and drones.
   - Modelling future land-use.
   - Spatial optimization and trade-offs relative to biodiversity, agriculture and energy production.

2. Social perception and of landscapes:
   - Impact of urbanization on human-nature interactions
   - Approaches in planning urban landscapes
   - Theories on landscape preference and place identity.
   - The role of landscapes for recreation, health and well-being
   - Methods of investigating the human-landscape relationship and evaluating interventions

Lecture notes
Handouts will be available in the course and for download

Prerequisites / notice
Basic Landscape Ecology courses at Bachelor level and basic knowledge of the R programming language

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking

701-1631-00L Foundations of Ecosystem Management

Abstract
This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

Objective
Students should be able to
a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.
b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.
Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental wellbeing. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

### Competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Decision-making</td>
<td>Communication</td>
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<td>Cooperate and Teamwork assessed</td>
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<td>Customer Orientation fostered</td>
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<td>Leadership and Responsibility fostered</td>
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<td>Self-presentation and Social Influence assessed</td>
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<td>Sensitivity to Diversity fostered</td>
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<td>Negotiation assessed</td>
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### Personal Competencies

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<th>adaptability and flexibility</th>
<th>Critical Thinking</th>
<th>Integrity and Work Ethics</th>
<th>Sensitivity to Diversity</th>
<th>Self-Presentation and Social Influence</th>
<th>Self-Direction and Self-Management</th>
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### Lecture notes

- Reading of articles in scientific journals
- The "Term Paper" requires considerable time set aside to read and digest original scientific literature, culminating in the writing of a review paper. The submission deadline is the first day of the spring semester, implying that much of the actual writing will be performed in January and February. Grading is based on the quality of the submitted review paper (2/3 of total grade), and on the "soft skills" such as the level of initiative, timeliness, independence, etc. of the student (1/3 of total grade). The personal supervisor is charged with grading the student's performance.
Quantitative and Computational Expertise

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-1411-00L</td>
<td>Environmental DNA - Concepts and Applications for Biodiversity Monitoring at the Landscape Scale</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>L. Pellissier, C. P. Albouy, K. Deiner, A. Frossard</td>
</tr>
</tbody>
</table>

Abstract
Environmental DNA (eDNA) allows the detection of organisms from traces of their DNA sampled from water, air or soil. Sampling eDNA instead of organisms makes monitoring fast, non-invasive, scalable and inexpensive. In this lecture, students will learn about eDNA and how it can be sampled, sequenced and analysed for biodiversity discovery and monitoring.

Objective
At the end of this course, participants should be able to:
- describe what eDNA is and how to harness the information in eDNA to turn it into a survey method for biodiversity
- describe the eDNA analytical steps, from the sampling, laboratory, data analysis and interpretation.
- summarise the common software and analytical tools for analysing eDNA data and be able to interpret the results.
- apply eDNA methods to design programs for monitoring in conservation and restoration through case studies.

Additionally, participants should be able to:
- provide constructive feedback to peers and learn from feedback,
- integrate concepts within and among disciplines of science.

Content
The course is consisting of two pillars:

Pillar 1: Theoretical background. The first pillar offers general theoretical knowledge about the nature of eDNA and its use in biodiversity science. It is structured into theoretical blocks with video content about sampling design, laboratory and data processing, which offer fundamental knowledge to solve the practical case studies of pillar 2.

Pillar 2: Data application on applied Case Studies. Each theory block will be associated with an exercise in which students are challenged to apply their knowledge from the theory. Students will collaborate on planning eDNA sampling design, visit the laboratory, run eDNA analysis (in R) following the best guidelines and interpret the results of analyses. These exercises will happen in person in the classroom.

Quantitative Vegetation Dynamics: Models from Tree to Globe

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1677-00L</td>
<td>Quantitative Vegetation Dynamics: Models from Tree to Globe</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>H. Lischke, U. Hiltner, B. Rohner</td>
</tr>
</tbody>
</table>

Abstract
The course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience.

Objective
Students will
- be enabled to understand, assess and evaluate the fundamental properties of dynamic systems using vegetation models as case studies
- obtain an overview of dynamic modelling techniques and their applications from the individual plant to the global level
- understand the basic assumptions of the various model types, which dictate the applicability and limitations of the respective model
- be enabled to work with such model types on their own
- appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems.

Content
Models of individuals
- Deriving single-plant models from inventory measurements
- Plant models based on 'first principles'

Models at the stand scale
- Simple approaches: matrix models
- Competition for light and other resources as central mechanisms
- Individual-based stand models: distance-dependent and distance-independent
- Theoretical models

Models at the landscape scale
- Simple approaches: cellular automata
- Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
- Landscape models

Global models
- Sacrificing local detail to attain global coverage: processes and entities
- Dynamic Global Vegetation Models (DGVMs)
- DGVMs as components of Earth System Models

Lecture notes
Handouts will be available in the course and for download

Laboratory and Field Expertise

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1425-01L</td>
<td>Genetic Diversity: Techniques</td>
<td>W</td>
<td>2 credits</td>
<td>4P</td>
<td>A. M. Minder Pfyl</td>
</tr>
</tbody>
</table>

Abstract
This course provides laboratory training for advanced students (master, doctoral or post-doctoral level). Various DNA/RNA extraction protocols, quality control measurements, SNP genotyping and gene expression techniques will be addressed. This is a course for practitioners.

Objective
To learn and improve on standard and modern methods of genetic data collection. With a focus on: Use of different DNA/RNA extraction protocols, techniques for DNA/RNA quality control measurements, gene expression and SNP genotyping techniques.
Content
After an introduction (one afternoon), students have 3 weeks to work independently in groups of two on different protocols. At the end of this practical part, the whole class meets for another afternoon to present the techniques/results and to discuss the advantages and disadvantages of the different techniques.

Techniques addressed are: RNA/DNA extractions and quality control, SNP genotyping and real-time qPCR.

Prerequisites / notice
There will be two afternoons in class. The lab work in between the afternoons is done by the students according to their own schedule but with the support of the teacher and must be completed after 3 weeks. The workload is approximately 1-2 full days per week, depending on the student's ability. Student must know how to pipette.

Lecture notes
Material will be handed out in the course.

Literature
Material will be handed out in the course.

Course notes and power point presentations provided during the course.

701-1437-00L Aquatic Ecology I
W 3 credits 3V A. Narwani, F. Altermatt, F. Pomati, C. T. Robinson, to be announced

Abstract
This course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with rivers, groundwater and lakes.

Objective
During this course you will get an overview of the world's typical freshwater ecosystems. After this course you will be able to understand how aquatic organisms have adapted to their habitat and how the interactions (e.g. food web) between organisms work.

In short: apply the theoretical / lecture knowledge to field situations in a lake and river.

Content
The lectures cover ecology and evolution of aquatic organisms in lentic and lotic waters. Topics include: Adaptations, distribution patterns, biotic interactions, and conceptual paradigms in freshwater ecosystems. Important aspects regarding ecosystem metabolism and habitat properties of freshwaters. Applied case studies and experiments testing ecological and evolutionary processes in freshwaters.

The lectures are given by Anita Narwani (Eawag), Florian Altermatt (UNI, Eawag), Chris Robinson (Eawag), Francesco Pomati (Eawag), Alexandra Weber (Eawag) and specialists from the Aquatic Ecology department of Eawag and University of Zurich.

Lecture notes
Course notes and power point presentations provided during the course.

Competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>fostered</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>fostered</td>
</tr>
</tbody>
</table>

701-1437-03L Aquatic Ecology II
W 5 credits 6U A. Narwani, F. Altermatt, F. Pomati, C. T. Robinson

Number of participants is limited. The maximal participating number of students is 8 from D-USYS and 16 from D-BIOL (ETH & UZH).

Target groups only: Bachelor Biology, Master Environmental Sciences and UZH MNF Biology.

Abstract
This course builds on Aquatic Ecology I and cannot be taken separately. It aims on extending the covered concepts and apply them to natural and experimental systems.

The course contains research projects, a 1-day excursion to a lake as well as a 3-day excursion to a river.

Objective
During the research project you will learn the principles of doing research to observe interrelations in aquatic ecosystems. You will measure and interpret biological and physical data (e.g. during experiments, field work). You will present the collected knowledge and write a report about it.

During the excursions you will get to know a lake system as well as a river system. The main goal of the excursions is that the students as a team conduct their own field research project and collect data in the field.

Content
The experimental part contains research projects in small groups within research groups at Eawag.

Lecture notes
Course notes and power point presentations provided during the course.

Prerequisites / notice
This course can only be taken together with "701-1437-00 Aquatic Ecology I", "701-1437-01 Bestimmungskurs aquatische Makroinvertebraten" and "701-1437-02 Bestimmungskurs Süsswasserorganismen und aquatische Mikroinvertebraten".

The maximal participating number of students is 8 from D-USYS and 16 from D-BIOL (ETH & UNI).

Registration for the course until 12.08.2024, free places will be distributed after that. Students registrating later cannot be guaranteed a place in the course.

The course includes a mandatory field trip to Greifensee (19.09.2024) and a three-day excursion to the river Glatt (25.-27.09. 2024).
### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

#### Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

### Expertise in Biological Diversity

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1437-01L</td>
<td>Practical Course Macroinvertebrates</td>
<td>W</td>
<td>2</td>
<td>2P</td>
<td>J. Jokela</td>
</tr>
</tbody>
</table>

The maximal participating number of students is 12 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I", "701-1437-03 Aquatic Ecology II" and "701-1437-02 Bestimmungskurs Süßwasseralgen und aquatische Mikroinvertebraten" are given priority. Sign in until 12.08.2024, free places will be distributed after that. Students registering later cannot be guaranteed a place in the course.

#### Abstract
This course gives an overview of the typical aquatic macroinvertebrate groups in Switzerland. Beside a theoretical background on the different groups the focus is laid on the determination of the most important species groups and their identification traits, also using identification keys. Practical experience in benthic sampling techniques is collected during an excursion.

#### Objective
During this course you will get an overview of the typical aquatic macroinvertebrates in Switzerland and the common sampling and preservation techniques. After this course you will be able to identify the most important aquatic species groups at the level of order/family and know the most important identification traits. You will also be able to use identification literature commonly used in Switzerland.

During an excursion, you will apply the theoretical identification knowledge to field situations.

#### Content
The taxonomic part will cover macroinvertebrates (e.g. Crustacean, aquatic insects). The goal is to get to know the most common aquatic taxa in Switzerland, to identify them with commonly used identification literature, and to get an idea how these organisms are used in research and practice. (language: German, translation of the most important things during the course possible)

The field excursion takes place Tuesday 22.10.2024.

#### Lecture notes
Course notes and power point presentations provided during the course.

#### Prerequisites / notice
The maximal participating number of students is 12 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I", "701-1437-03 Aquatic Ecology II", and "701-1437-01 Bestimmungskurs aquatischer Makroinvertebraten" are given priority. Sign in until 12.08.2024, free places will be distributed after that. Students registering later cannot be guaranteed a place in the course.

The field excursion takes place Tuesday afternoon 22.10.2024 from 1pm-5pm.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered

#### Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

#### Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

<table>
<thead>
<tr>
<th>Number</th>
<th>Identification Course Freshwater Algae and Aquatic Microinvertebrates</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1437-02L</td>
<td></td>
<td>W</td>
<td>2</td>
<td>2P</td>
<td>J. Jokela</td>
</tr>
</tbody>
</table>

The maximal participating number of students is 12 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I", "701-1437-03 Aquatic Ecology II", and "701-1437-01 Bestimmungskurs aquatischer Makroinvertebraten" are given priority. Sign in until 12.08.2024, free places will be distributed after that. Students registering later cannot be guaranteed a place in the course.
Abstract

This course gives an overview of the typical aquatic microinvertebrate and freshwater algae groups in Switzerland. Beside a theoretical background of the different groups the focus is laid on the recognition of the most important species groups and their identification traits. Practical experience is collected during an excursion.

Objective

During this course you will get an overview of the typical aquatic microinvertebrates (e.g. zooplankton) and algae in Switzerland. You will also get to know commonly used sampling techniques. After this course you will know the most important aquatic species groups and the most important identification traits.

You will apply the theoretical knowledge during an excursion.

Content

The taxonomic part will cover microinvertebrates and freshwater algae. The goal is to get to know the most common aquatic taxa in Switzerland, to identify them and to get an idea how these organisms are used in research and practice. (language: German, translation of the most important things during the course possible)

Lecture notes

The identification exercise takes place Thursday 17.10.2024 from 1pm-5pm.

Prerequisites / notice

The maximal participating number of students is 12 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I" and "701-1437-01 Bestimmungskurs aquatischer Makroinvertebraten" are given priority. Sign in until 12.08.2024 free places will be distributed after that. Students registrating later can not be guaranteed a place in the course.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies

- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Electives

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0290-00L</td>
<td>Seminar in Microbial Evolution and Ecology (HS)</td>
<td>Z</td>
<td>0</td>
<td>2S</td>
<td>G. Velicer</td>
</tr>
</tbody>
</table>

Abstract

Seminar of the groups Molecular Microbial Ecology, Theoretical Biology, Experimental Ecology, Evolutionary Biology. Talks given by members of these groups and external visitors.

Objective

In-depth introduction into microbial evolution and ecology, especially the aspects that are the focus of on-going research in this area at Department of Environmental Systems Science.

Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Media and Digital Technologies

Social Competencies

- Communication
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

701-3001-00L     | Environmental Systems Data Science: Data Processing                | W    | 2    | 2G   | L. Pellissier, C. P. Albov, M. Volpi |

Abstract

Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective

The students are able to

- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content

- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication
Prerequisites / notice
252-0840-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

701-3003-00L Environmental Systems Data Science: Machine Learning

Prerequisites / notice
252-0840-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

551-0205-00L Challenges in Plant Sciences

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I

751-4504-00L Plant Pathology I

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I
The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytotoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.


Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.


Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Lecture notes: Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

Competencies:
- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Assessed:
- Lecturers

Major in Environmental Systems Policy

Theoretical Foundations for Environmental Policy

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1563-00L</td>
<td>Climate Policy</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>A. Patt., S. Hanger-Kopp</td>
</tr>
</tbody>
</table>

Abstract:
This course provides an in-depth analysis of climate policy development and climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.

Objective:
The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.
Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 20 to 30 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It's a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows' bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

### Literature
There will be reading assignments for select classes. All of these will be posted in PDF format on a course Moodle. In addition, there will be one book and one report to be read over the course of the semester. They are:

- Ministry of the Future, by Kim Stanley Robinson

### Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.</td>
<td>Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.</td>
<td>In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>To analyze the evolution as well as the key elements of environmental governance.</td>
<td>Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of 'environmental governance' and how legitimate and effective are these approaches in addressing persistent environmental challenges?</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td></td>
<td>Furthermore, we encourage the development of soft skills by engaging students in activities such as moderating discussions in class, presenting own proposals, giving regular peer feedback, as well as critically reflecting on various relevant publications in the environmental governance domain.</td>
</tr>
</tbody>
</table>

### Prerequisites / notice
- Lecture notes
- Literature
- Competencies
- Decision-making
- Problem-solving
- Communication
- Negotiation
- Creative Thinking
- Critical Thinking

### Literature
- Ten Principles for Policy Making in the Energy Transition, by Laura Diaz Anadon et al.
- Methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

### Prerequisites
- sociology, history, psychology, philosophy)
- introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)
The course provides an overview of dominant and emerging trends in the theory and practice of environmental governance. The course

Communication
To gain an overview of the history of the transition of large technical systems
Concepts and Theories

University lecturers

2V
Governing the Energy Transition

This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and

Analytical Competencies
- To gain knowledge on the role of policy and politics in energy transitions
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions

Prerequisites / notice
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

Adaptability and Flexibility
assessed

Creative Thinking
fostered

Critical Thinking
assessed

Integrity and Work Ethics
assessed

Self-awareness and Self-reflection
assessed

Self-direction and Self-management
assessed

The course provides an overview of dominant and emerging trends in the theory and practice of environmental governance. The course

Social Competencies
Communication
- To gain an overview of the history of the transition of large technical systems
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

701-1590-00L Geographies of Environmental Governance (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 07SMGEO837
https://studentservices.uzh.ch/uzh/anonymous/vz2/?sap-language=DE&sap-ui-language=DE

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract
The course provides an overview of dominant and emerging trends in the theory and practice of environmental governance. The course

Objective
Course participants will develop a theoretically as well as practically informed understanding of recent issues and debates in contemporary
geographies of environmental governance.

Content
The course provides an overview of dominant and emerging trends in the theory and practice of environmental governance. The course

Analytical Competencies
- To gain knowledge on the role of policy and politics in energy transitions
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions

Literature
A reading list will be provided via moodle.ethz.ch at the beginning of the semester.

Prerequisites / notice
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

851-0609-06L Governing the Energy Transition

Primarily suited for Master and PhD level.

Abstract
This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-

Objective
- To gain an overview of the history of the transition of large technical systems
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions

Content
Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015

Literature
A reading list will be provided via moodle.ethz.ch (only for registered students).

Prerequisites / notice
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

860-0023-00L International Environmental Politics

Particularly suitable for students of D-ITET, D-USYS.

Abstract
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and

Objective
The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a

Content
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and

Literature
Reading materials and slides will be available via Moodie.

Data: 02.07.2024 12:39
Autumn Semester 2024
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The lectures will introduce students to the principles of quantitative policy analysis, namely the methods to predict and evaluate the social, economic, and environmental effects of alternative strategies to achieve public objectives. A series of individual assignments, and one group project, will give students an opportunity for students to apply those methods to a set of case studies.

The objectives of this course are to develop the following key skills necessary for policy analysts:
- Identifying the critical quantitative factors that are of importance to policy makers in a range of decision-making situations.
- Developing conceptual models of the types of processes and relationships governing these quantitative factors, including stock-flow dynamics, feedback loops, optimization, sources and effects of uncertainty, and agent coordination problems.
- Develop and program numerical models to simulate the processes and relationships, in order to identify policy problems and the effects of policy interventions.
- Communicate the findings from these simulations and associated analysis in a manner that makes transparent their theoretical foundation, the level and sources of uncertainty, and ultimately their applicability to the policy problem.

The course will proceed through a series of policy analysis and modeling exercises, involving real-world or hypothetical problems. The specific examples around which work will be done will concern the environment, energy, health, and natural hazards management.

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<td>701-1565-00L</td>
<td>Quantitative Policy Analysis and Modeling</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>A. Patt, L. Booth, C. Moretti, T. Tröndle</td>
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The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

Credits and Exam
After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. Students who obtain a grade of < 4.0 for the test will have a second chance (see table below). Students who did not participate in the test on 18 December 2023 will not have access to the repeat test unless they submit compelling and documented (e.g. medical, other exam in parallel at ETH) reasons for why they were unable to participate in the first test. It covers all contents of the lectures and the reading assignments. Visiting students (e.g., from the University of Zurich or other universities) are subject to the same conditions. Registration for the course in the mystudies system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.

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The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

Objective
Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

Lecture notes
Powerpoint slides are available on the moodle page. Additional documents are handed out as copies.

Literature
Basic literature and references are listed on the webpage.

Prerequisites / notice
Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

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<td>701-1453-00L</td>
<td>Ecological Assessment and Evaluation</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>F. Knaus</td>
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Abstract
The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.
This course provides an introduction to agent-based models for transportation policy analysis. The lectures and exercises offer an opportunity to learn about agent-based simulation models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in groups.

Objective
At the end of the course, the students should:
- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform transportation studies

Content
This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained. Here the open-source eqasim framework used at ETH Zurich to set up agent-based models will be introduced
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).
Agent-based modeling in general

MATSim

Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

Prerequisites / notice
There are no strict prerequisites regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

For those without object-oriented programming experience, a crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

Competencies
Subject-specific Competencies
Techniques and Technologies: assessed
Analytical Competencies: fostered
Problem-solving: assessed
Project Management: fostered
Social Competencies
Cooperation and Teamwork: fostered
Personal Competencies
Critical Thinking: assessed

363-0541-00L Economic Dynamics and Complexity W 3 credits 3G F. Schweitzer, L. Verginer

Abstract
What causes economic business cycles? How are limited resources, competition, and cooperation reflected in growth dynamics? To answer such questions, we combine macroeconomic models and methods of nonlinear dynamics. We study the role of bifurcations and control parameters for dynamic stability. Feedback cycles and coupled dynamics are reasons for limited predictability, instability and chaos.

Objective
Successful participant of the course is able to:
- understand the importance of different modeling approaches
- formalize and solve one- and two-dimensional nonlinear models
- identify critical conditions for stability and dynamic transitions
- analyze macroeconomic models of business cycles, supply and demand
- apply formal concepts to model economic growth and competition

Content
System theory sees the economy as a complex adaptive system. What does this mean for economic modeling?
We focus on two sources of complexity: (a) nonlinear dynamics, which is captured in this course, “Economic Dynamics and Complexity” and (b) collective interactions, which is captured in the course “Agent-Based Modeling of Economic Systems” (in Spring).

Our approach to economic dynamics combines insights from different disciplines: macroeconomics studying business cycles and growth, system dynamics rooted general system theory and cybernetics, and nonlinear dynamics using applied mathematics.

We start with a comparison of different modeling approaches, to highlight the problems and challenges of system modeling. The subsequent lectures then introduce different one- and two-dimensional nonlinear models with applications in economics, such as models of supply and demand, business cycles, growth and competition. Emphasis is on the formal analysis of these models using methods from applied mathematics and tools for solving coupled differential equations.

Weekly self-study tasks are used to apply the concepts introduced in the lectures.
We practice how to solve nonlinear models formally and numerically and how to interpret the results.

Lecture notes
The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

Prerequisites / notice
Students should be familiar with nonlinear differential equations and should have basic programming skills. All necessary details to solve nonlinear models will be provided in the course. The course will not build on mathematical proofs, optimization, statistics, efficient numerical computation and other specialized skills.

Competencies
Subject-specific Competencies
Concepts and Theories: assessed
Analytical Competencies: assessed
Decision-making: fostered
Problem-solving: assessed
Social Competencies
Communication: fostered
Cooperation and Teamwork: fostered
Personal Competencies
Creative Thinking: assessed
Critical Thinking: assessed
Integrity and Work Ethics: fostered
Self-awareness and Self-reflection: fostered

Policy Engagement

701-1563-00L Climate Policy W 6 credits 4G A. Patt, S. Hanger-Kopp

Abstract
This course provides an in-depth analysis both of the theoretical underpinnings to different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.

Objective
The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.
Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 20 to 30 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG's from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It's a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows' bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

There will be reading assignments for select classes. All of these will be posted in PDF format on a course Moodle. In addition, there will be one books and one report to be read over the course of the semester. They are:

- Ministry of the Future, by Kim Stanley Robinson
- Ten Principles for Policy Making in the Energy Transition, by Laura Diaz Anadon et al.

**Competencies**

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**751-2107-00L Agrarian and Environmental Values: Tensions, Synergies, Practices and Policies**

*Limited to 20 students.*

**Abstract**

In politics, society, and science, it can seem that the values and practices of agricultural production and environmental protection are in conflict. This tension is often described as “protection versus use” of natural resources. We will explore ways to move beyond the apparent conflict. We will apply this learning to field trips and transdisciplinary projects.

**Objective**

Students are able to:

- Define different kinds and categories of values.
- Relate value concepts to their own studies, life, and experiences through reflective journaling.
- Infer the underlying values in a text or policy about agri-environmental topics.
- Collaboratively develop a transdisciplinary project for an agri-environmental case study from the field trips.

**Content**

The course consists of interactive seminars alongside fieldtrips to farms that have found innovative solutions to balancing protection and production.

Seminars will cover topics such as the relationship between values and behavior and how people perceive value trade-offs. We will also discuss environmental ethics, environmental valuation and its critiques, the interplay of facts and values in agri-environmental decision-making, cultural ecosystem services, and relational values.

This class requires active participation. Learning is based on in-class activities, group work and fieldtrips.
Literature

Literature will draw from political ecology, value theory and environmental values, as well as case studies and primary texts, such as the following (not all will be required reading; we will read 1 or 2 papers or book chapters each week).


Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Sensitivity to Diversity

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Electives

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
701-1590-00L | Geographies of Environmental Governance (University of Zurich) | W | 3 credits | 2G | University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: 07SMGEO837 https://studentservices.uzh.ch/uzh/anonym/vvz/?sap-language=DE&sapid=DE#details/2023/003/SM/50890034
This course introduces landscapes as socially perceived, spatially and temporally dynamic entities that are shaped by natural and societal factors. Concepts and qualitative and quantitative methods to study landscapes from an ecological and societal perspective are presented. The course consists of a mixture of theoretical lectures and exercises or practical sessions.
Objective

Students will learn:
- The use of spatial data and analyses for quantifying patterns and processes in landscapes
- Concepts and methods to quantify functional connectivity in landscapes and seascapes.
- The use of remote sensing (satellites images, drones) to extract information about landscape structure and change, with a focus on land-use
- The use of landscape genetics and its application to biodiversity conservation.
- To computationally optimize land-use planning problems.
- Concepts and methods in scenario-based land-use change modelling.
- Landscape ecological concepts and planning tools for management of urban landscapes.
- Concepts of social preference of landscapes and related measurement methods.
- how to design urban environments that foster health and well-being
- The role of landscape features in influencing human well-being.
- Approaches of actively influencing attitudes and behavior toward landscapes as well as their scientific evaluation.

Content

Thematic topics
1. Ecological quantification of landscape patterns:
- Landscape resources and green infrastructure (e.g., ecological conservation areas).
- Landscape genetics and conservation applications.
- Concepts of spatial quantitative methods: least cost paths, resistance surfaces, Circuitscape, land-use change models, various statistical methods.
- Image processing from remote sensing from satellites and drones.
- Modelling future land-use.
- Spatial optimization and trade-offs relative to biodiversity, agriculture and energy production.

2. Social perception and of landscapes:
- Impact of urbanization on human-nature interactions
- Approaches in planning urban landscapes
- Theories on landscape preference and place identity.
- Methods of investigating the human-landscape relationship and evaluating interventions

Lecture notes
Handouts will be available in the course and for download

Prerequisites / notice
Basic Landscape Ecology courses at Bachelor level and basic knowledge of the R programming language

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking

ECTS
5 credits

701-1644-00L Mountain Hydrology W 5 credits 3G M. Brunner, K. Meusburger Di Bella

Abstract
This course presents a process-based view of the hydrology of mountain streams. Students learn how to integrate process knowledge, data, and models to understand how landscapes regulate the fluxes of water, sediment, nutrients, and pollutants in streams, and to anticipate how streams will respond to changes in land use, water use, and climate.

Objective
Main learning objectives:
- Describe the main elements and processes and their interlinkages of the water cycle in mountain catchments and analyze their characteristics and changes.
- Identify and describe the important components of the water cycle and their influencing factors and discuss how changes in these influencing factors may affect different parts of the hydrological cycle.
- Explain how hydrological data are collected, how hydrological models work, how they are calibrated, and how they are evaluated.

Content
Streams are integrated monitors of the health and functioning of their surrounding landscapes. Streams integrate the fluxes of water, solutes, and sediment from their contributing catchment area; thus they reflect the spatially integrated hydrological, ecophysiological, biogeochemical, and geomorphological processes in the surrounding landscape. At a practical level, there is significant public interest in managing upland landscapes to provide a reliable supply of high-quality surface water and to minimize the risk of catastrophic flooding and debris flows, but the scientific background for such management advice is still evolving.

Using a combination of lectures, field exercises, and data analysis, we explore the processes controlling the delivery of water, solutes, and sediment to streams, and how those processes are affected by changes in land cover, land use, and climate. We review the connections between process understanding and predictive modeling in these complex environmental systems. Practical problems to be considered include the effects of land use and climate on streamflow and water quality, illustrated with data from experimental watersheds in North America and Europe.

Lecture notes
Handouts will be available through moodle.

Literature
Recommended and required reading will be specified at the first class session (with possible modifications as the semester proceeds).

Number Title Type ECTS Hours Lecturers

Autumn Semester 2024
The course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

Students should be able to:
- Propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.
- Identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Bundling up a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

701-1635-00L

Foundation of Ecosystem Management

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701-1635-00L

Multifunctional Forest Management

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<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Communication fostered</td>
<td>Adaptability and Flexibility fostered</td>
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<td>Cooperation and Teamwork assessed</td>
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<td>Integrity and Work Ethics fostered</td>
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<td>Self-presentation and Social Influence assessed</td>
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<td>Sensitivity to Diversity fostered</td>
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Forests provide a variety of ecosystem goods and services. Multifunctional forest management attempts to control natural processes in a sustainable and near-natural way so that various requirements from the society can be met. Adaptivity to changing conditions (global changes), handling of conflicting goals and the development of alternative management strategies are of central importance.

At the end of this course participants will be able:
- To describe forest management and silvicultural measures for enhancing forest resilience to climate change, increased disturbances, and invasive species, and evaluate their feasibility and effectiveness in various situations;
- To concisely describe silvicultural options for the management of multifunctional forests and critically evaluate their feasibility and suitability;
- To explain the various social expectations towards forest ecosystem services and their implications for multifunctional forest management and critically analyse conflicts and synergies resulting from different forest ecosystem services;
- To carry out research on a given topic, identify relevant literature and present the results in a structured presentation and discuss the implications for forest management.

The course will cover important topics for the sustainable management of multifunctional forests and present silvicultural strategies to fulfil a variety of forest ecosystem goods and services. Current and future challenges of forest management will be presented. The course is structured into the following sub-topics:
1) Forest management under climate change and increasing disturbances.
2) Invasive alien species: Implications for forest management.
3) Non-native tree species: Risks, opportunities and management options.
4) Silvicultural and management options in multifunctional forests.
5) Challenges and silvicultural strategies for wood production.
6) Forest management and biodiversity in temperate forests.

No class notes or text books

Lecture notes are available for download

Literature

Lecture presentations are provided for the group presentations.
In addition to the lectures, students need to attend 4 all-day field excursions. Excursion topics: Forest management and climate change, Nature-based silvicultural concepts; Soil protection and forest management; Continuous cover forestry.

Participation at all 4 full-day excursions is a prerequisite for the credits. Excursions are held in English, German and French (some German and French knowledge is good to have).

Additional field excursions focusing on silvicultural systems and multifunctional forest management will be offered during the spring semester in the optional course "Selected Topics of Multifunctional Forest Management". 9 all-day field trips will provide the possibility to consolidate theoretical knowledge, to apply it to real examples in the field, to discuss with forest practitioners and further consolidate what has been taught in this course. The additional course is an important part of the formation of the Major in Forest and Landscape and is highly recommended.

### Decision Making, Policy and Planning

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<th>Number</th>
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<th>Hours</th>
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<tr>
<td>701-1651-00L</td>
<td>Environmental Governance</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>E. Lieberherr</td>
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</tbody>
</table>

**Abstract**
The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

**Objective**
To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

To analyze the evolution as well as the key elements of environmental governance.

To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

**Content**
Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors’ behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of ‘environmental governance’ and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Furthermore, we encourage the development of soft skills by engaging students in activities such as moderating discussions in class, presenting own proposals, giving regular peer feedback, as well as critically reflecting on various relevant publications in the environmental governance domain.

**Lecture notes**
Lecture slides, a script and additional course material will be provided on Moodle.

**Prerequisites / notice**
A detailed course schedule will be made available at the beginning of the semester. During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)
Competencies

Subject-specific Competencies
- Concepts and Theories
  - assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - assessed
- Problem-solving
  - assessed
- Project Management
  - assessed

Social Competencies
- Communication
  - assessed
- Cooperation and Teamwork
  - assessed
- Self-presentation and Social Influence
  - assessed
- Sensitivity to Diversity
  - assessed
- Negotiation
  - assessed

Personal Competencies
- Adaptability and Flexibility
  - assessed
- Creative Thinking
  - fostered
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - assessed
- Self-awareness and Self-reflection
  - assessed
- Self-direction and Self-management
  - assessed

Abstract

This course covers and integrates knowledge from the disciplines of landscape level forest management planning, ecology, and forest economics. Students will apply knowledge and methods acquired throughout their studies to real world case studies, and will learn to make predictions about the development of forest ecosystems, prescribe realistic management solutions, and assess the economic consequences.

Objective

After participating in this course, students will be able to:
- Identify and integrate environmental, social and economic objectives for managing a forest.
- Design landscape level forest management concepts to meet these objectives.
- Identify criteria and indicators appropriate for assessing and monitoring the success of alternative forest management approaches in achieving their objectives.
- Apply standard procedures for cashflow-based evaluations to review the economic sustainability of different forest management scenarios.
- Develop forest-based business proposals including income from traditional timber harvesting operations and complementary sources.

Additionally, students will practice and enhance soft skills – such as providing constructive feedback to peers – or by learning to effectively work in diverse teams.

Content

What is forest management planning (FMP)? What is a Waldentwicklungsplan?

Basic definitions of forests as complex dynamic systems in the context of forest management planning.

The history of FMP and classic approaches to calculating sustained yield (Cotta, Hartig).

Components and structure of a sustainable forest management plan (SFMP).

The planning process and timber supply modelling.

Determining long-term sustained yields and allowable annual cut in clear cutting and close to nature systems.

Management choices and how they impact timber supply.

Certification standards and the use of criteria and indicators (taught by FSC externals).

Introduction to Business Planning and Financial evaluation in forestry.

Faustmann and the Land expectation value.

Calculating internal rates of return.

Choice experiments and valuing forest attributes.

Payments for ecosystem services.

Economics of risk, uncertainties and natural disturbances.

Economics of forest property rights and certification.

Methods and Tools

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
701-1673-00L | Environmental Measurement Laboratory | W | 5 credits | 4G | P. U. Lehmann Grunder, A. Carminati

Abstract

Measurements are the sole judge of scientific truth and provide access to unpredictable information, enabling the characterization and monitoring of complex terrestrial systems. Based on lectures and field- and laboratory training, the students learn to apply modern methods to determine forest inventory parameters and to measure subsurface properties and processes.

Objective

The students will be able to:
- explain measurement principles that are used for characterization of landscapes and terrestrial systems
- select appropriate measurement methods and sampling design to quantify key variables and processes above ground and in the subsurface
- deploy sensors in the field
- interpret collected laboratory and field data and report main conclusions deduced from measurements
**Content**

Week 1: Plant-Soil interactions – short introduction before sensor demonstration and installation in forest lab; Scholander pressure bomb (suction in leaves); LiCOR soil chamber

Weeks 2 to 6 - Experimental Methods for Soil Health Assessment

- Week 2: Lecture on soil health and soil indicators; defining measurable soil health indicators for case studies for different soil threats and climate regions
- Week 3: Short lecture on sampling, sensors and data logging; preparing sensors and data loggers in the lab; measurements on water content and temperature in the lab
- Week 4: Short introduction on field installation; sensor installation at field site Hönggerberg
- Week 5: Lecture on geophysical methods on subsurface characterization: basic principles of ERT, GPR, and EM; planning of field experiment to assess soil health
- Week 6: Short introduction on data analysis; field sampling and conducting field experiment to assess soil health

Week 7: Analysis of experimental data and soil health assessment; poster presentation and discussion

Week 8: Lecture on plant soil relationship; connecting information below and above ground – data analysis

Weeks 9 and 10: Forest characterization/inventory: Principles of LiDAR; structures and features of the tree crowns, size/volume of the leaf area tree positions and diameters at breast height

Weeks 11 and 12: Eddy covariance methods -Principles for field measurement of water vapor, carbon dioxide, and energy exchange between terrestrial surfaces and the atmosphere; Analysis of measured time series to determine evaporation rate and CO2-fluxes

Week 13: Swiss Soil Monitoring networks – Monitoring of soil water content and potential; climate change and droughts

Week 14: Global data – Global modeling and data interpretation; SoilGrids and OpenLandMap; exercises on Budyko analysis

**Literature**

Lecture material will be online for registered students using moodle

**Prerequisites / notice**

The details of the schedule will be optimized based on the number of students; some blocks of the course will be offered as well to students of Environmental Engineering

**Competencies**

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Decision-making
- Problem-solving
- Project Management

Method-specific Competencies
- Communication
- Cooperation and Teamwork

Social Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Personal Competencies
- fostered

**Electives**

- Natural Science Foundations

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
701-1343-00L | Soil-Plant Water Relations | W | 3 credits | 2V | A. Carminati

**Abstract**

Water limitation is a primary constraint on plant growth and terrestrial fluxes worldwide. In this course, the principles of water flow in soil and plants are discussed, with particular attention on the effect of drought on root water uptake, transpiration and plant growth. Strategies of plants to tolerate drought are discussed in relation to both agricultural and ecological implications.

**Objective**

The students are able to: explain and compare systematically the drivers of water stress to plants; to solve the equations of water flow in soil and plants and to calculate plant water status for varying soil and climatic conditions and plant traits; to critically review and present one research question in soil-plant water relations; to openly debate on the current trends in soil and plant water research and climate change ecology.

**Content**

Part 1 - Lectures
- Week 1: Introduction.
- Week 2: Soil water relations; Principles of soil water retention and soil water flow; Soil hydraulic properties.
- Week 3: Root water uptake; soil hydraulic constraints on transpiration
- Week 4: Rhizosphere processes and properties; root-soil contact; root hairs; mycorrhiza; rhizodeposition.
- Week 5: Water flow in roots and xylem; root anatomy, architecture and plasticity; cavitation.
- Week 6: Transpiration; Vapor Pressure Deficit; Photosynthesis; Stomatal regulation.
- Week 7: Soil-plant-atmospheric continuum; Below- and above-ground feedbacks; Soil and atmospheric drivers of transpiration losses.

Part 2 - Seminar
- Week 8: Plant response to drought and consequences for agriculture and forests. Open questions and introduction to seminar topics.
- Week 9: Class work - preparation of the presentations/Debate
- Week 10: Class work - preparation of the presentations/Debate
- Week 11: Seminar/Debate (presentations)
- Week 12: Seminar/Debate (presentations)
- Week 13: Seminar/Debate (presentations)
- Week 14: Feedback, Summary, Conclusion

**Literature**

Lecture notes; selection of articles

**Prerequisites / notice**

Vadose Zone Hydrology/Environmental Soil Physics (recommended but not required)
Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Method-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving
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- Self-presentation and Social Influence
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- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

701-1620-00L Tree Genetics – Concepts and Applications
- W
- 3 credits
- A. Rudow, F. Gugerli, C. Sperisen, K. Streit

Abstract
Trees are important elements and drivers of ecosystem processes in forests and landscapes. Tree species diversity and intraspecific genetic diversity are relevant factors for continuous adaptation, required for a sustainable maintenance of forest products and services. Sustainable forest and landscape management under climate change has to take forest genetic resources into consideration.

Objective
The educational goals of the course are:
- To know basic concepts of evolution and molecular and quantitative methods of genetics.
- To understand the most relevant processes of gene flow, adaptation and species interactions, on the basis of ecological theories and case studies on forest tree species.
- To know management principles and instruments for the promotion and the conservation of forest genetic resources, with a view on application in practice.

Content
The course provides a comprehensive overview on concepts and applications of tree genetics and complements basic knowledge of biology, dendrology, forest ecology and forest management in the frame of forest and landscape management topics. It introduces concepts of evolution and genetic methods as foundations, explains the most important processes and drivers of gene flow and adaptation, including coevolutionary aspects of associated organisms, and shows relevant topics of the management of genetic resources from reproduction to conservation and monitoring. Theories and their application into practice are illustrated on behalf of case studies on forest tree species. Two full-day excursions illustrate the contents with exemplary objects, actors and applications in Switzerland.

Lecture notes
Script: modular slide script (parts by each lecturer).
Textbook: collection of accompanying or background articles according to detailed contents (to be defined).

Literature

751-5125-00L Stable Isotope Ecology of Terrestrial Ecosystems
- W
- 2 credits
- R. A. Werner, N. Buchmann, A. Gessler, M. Lehmann

Abstract
This course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions.

Objective
Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small ISOProject, practice to search and analyze literature as well as to give an oral presentation.

Content
The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

Lecture notes
Handouts will be available on the webpage of the course.

Prerequisites / notice
This course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.

Autumn Semester 2024
### Decision Making, Policy and Planning

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<tr>
<td>751-2107-00L</td>
<td>Agrarian and Environmental Values: Tensions, Synergies, Practices and Policies</td>
<td>W</td>
<td>5 credits</td>
<td>3G</td>
<td>M. Chapman, J. Jacobi</td>
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**Limited to 20 students.**

**Abstract**

In politics, society, and science, it can seem that the values and practices of agricultural production and environmental protection are in conflict. This tension is often described as “protection versus use” of natural resources. We will explore ways to move beyond the apparent conflict. We will apply this learning to field trips and transdisciplinary projects.

**Objective**

Students are able to:

- Define different kinds and categories of values.
- Relate value concepts to their own studies, life, and experiences through reflective journaling.
- Infer the underlying values in a text or policy about agri-environmental topics.
- Collaboratively develop a transdisciplinary project for an agri-environmental case study from the field trips.

**Content**

The course consists of interactive seminars alongside fieldtrips to farms that have found innovative solutions to balancing protection and production.

Seminars will cover topics such as the relationship between values and behavior and how people perceive value trade-offs. We will also discuss environmental ethics, environmental valuation and its critiques, the interplay of facts and values in agri-environmental decision-making, cultural ecosystem services, and relational values.

This class requires active participation. Learning is based on in-class activities, group work and fieldtrips.
Literature will draw from political ecology, value theory and environmental values, as well as case studies and primary texts, such as the following (not all will be required reading; we will read 1 or 2 papers or book chapters each week).


Ecosystem Management

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<tr>
<td>701-1453-00L</td>
<td>Ecological Assessment and Evaluation</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>F. Knaus</td>
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</table>

Abstract

The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.
Objective

Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

Lecture notes

Powerpoint slides are available on the moodle page. Additional documents are handed out as copies.

Prerequisites / notice

The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

Abstract

The discipline of Forest operations is constantly challenged to find solutions for unique problems. Each forest site requires specific technological approaches and machinery based on given management goals and ecological and environmental circumstances. Various terrain types and soil conditions, harvesting costs and taking care of the workforce by creating safe working conditions are some of the aspects that contribute to the challenge. The course is aimed at students who either plan an academic or professional career in the field of forest operations, or who will work at the interface between forest operations and the various related disciplines, such as forest ecosystem management and forestry in the wider sense.

After participating in this course students will have acquired foundational knowledge of a wide variety of core elements in the field of forest operations:
• The course will provide students with the ability to describe and differentiate site and stand conditions from an engineering perspective.
• Students will gain an overview and good working knowledge of current technology used in forest operations in Switzerland and around the world.
• Students will acquire the ability to assess the strength and weaknesses of the most commonly used equipment and analyze their suitability for a given set of environmental, economic and social factors.
• Students will be able to combine different types of technology to create an optimal harvesting system for a given task, and assess a given system for its task specific suitability.
• Participants will be able to assess the sustainability and potential short- and long-term impacts of harvesting systems under ecological, economic and social constraints.

Competencies

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<td>Analytical Competencies</td>
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701-1645-00L Forest Operations  W 3 credits  2G  H. Griess, J. Schweier

Autumn Semester 2024
Content

Introduction
- Historic overview
- Scope of operation
- Site and stand characteristics

Timber harvesting
- Logging methods
- Felling methods
- Motor-Manual felling methods
  - Falling and processing
- Forest machine structure and function
- Harvester Technology
  - Felling heads
  - Carriers for felling heads
- Bunching
- Mechanical processing
- Loading equipment
- Operating techniques

Primary Transport Systems
- Ground based
  - Common features
  - Skidder
  - Forwarder
  - Loader Forwarder
- Cable yarding
  - Common features
  - Wire rope
  - Cable yarding systems
  - Operating techniques
- Aerial
  - Common features
  - Operating techniques

Winch-Assisted Harvesting Operations
- Harvesting
- Primary transport

Loading Equipment

Secondary transport
- Truck configurations
- Soil compaction and contamination
- Riparian areas

Forest Operations management
- Ergonomics
- Work Safety
- Economic Aspects
- Environmental impact assessment
- Equipment selection

Forest operations across the globe
- New Zealand
- North America
  - British Columbia, Canada
  - South-eastern U.S.A

Specialized equipment for small scale forest operations

Outlook into the future of forest operations

Literature
Published on Moodle
Prerequisites /
notice

701-1544-00 Forest Access and Transportation

Methods and Tools

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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-1411-00L</td>
<td>Environmental DNA - Concepts and Applications for Biodiversity Monitoring at the Landscape Scale</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>L. Pellissier, C. P. Albouy, K. Deiner, A. Frossard</td>
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</table>

Abstract

Environmental DNA (eDNA) allows the detection of organisms from traces of their DNA sampled from water, air or soil. Sampling eDNA instead of organisms makes monitoring fast, non-invasive, scalable and inexpensive. In this lecture, students will learn about eDNA and how it can be sampled, sequenced and analysed for biodiversity discovery and monitoring.

Objective

At the end of this course, participants should be able to:
- describe what eDNA is and how to harness the information in eDNA to turn it into a survey method for biodiversity
- describe the eDNA analytical steps, from the sampling, laboratory, data analysis and interpretation.
- summarise the common software and analytical tools for analysing eDNA data and be able to interpret the results.
- apply eDNA methods to design programs for monitoring in conservation and restoration through case studies.

Additionally, participants should be able to:
- provide constructive feedback to peers and learn from feedback,
- integrate concepts within and among disciplines of science.
The course is consisting of two pillars:

Pillar 1: Theoretical background. The first pillar offers general theoretical knowledge about the nature of eDNA and its use in biodiversity science. It is structured into theoretical blocks with video content about sampling design, laboratory and data processing, which offer fundamental knowledge to solve the practical case studies of pillar 2.

Pillar 2: Data application on applied Case Studies. Each theory block will be associated with an exercise in which students are challenged to apply their knowledge from the theory. Students will collaborate on planning eDNA sampling design, visit the laboratory, run eDNA analysis (in R) following the best guidelines and interpret the results of analyses. These exercises will happen in person in the classroom.

**Content**

- Basic understanding of genetics and molecular analyses.
- Basic knowledge of R and Geographic Information Systems (GIS).
- The analytic part of the lecture will rely on skills from "Environmental Systems Data Science"

**Prerequisites / notice**

- Basic knowledge of genetics and molecular analyses.
- Basic knowledge of R and Geographic Information Systems (GIS).
- The analytic part of the lecture will rely on skills from "Environmental Systems Data Science"

**Lecture notes**

Handouts will be available in the course and for download

**Literature**

Will be indicated at the beginning of the course

**701-1677-00L Quantitative Vegetation Dynamics: Models from Tree to Globe**

**Abstract**

The course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience.

**Objective**

- Students will
  - be enabled to understand, assess and evaluate the fundamental properties of dynamic systems using vegetation models as case studies
  - obtain an overview of dynamic modelling techniques and their applications from the individual plant to the global level
  - understand the basic assumptions of the various model types, which dictate the applicability and limitations of the respective model
  - be enabled to work with such model types on their own
  - appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems.

**Content**

Models of individuals
- Deriving single-plant models from inventory measurements
- Plant models based on "first principles"

Models at the stand scale
- Simple approaches: matrix models
- Competition for light and other resources as central mechanisms
- Individual-based stand models: distance-dependent and distance-independent
- Theoretical models

Models at the landscape scale
- Simple approaches: cellular automata
- Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
- Landscape models

Global models
- Sacrificing local detail to attain global coverage: processes and entities
- Dynamic Global Vegetation Models (DGVMs)
- DGVMs as components of Earth System Models

**Lecture notes**

Handouts will be available in the course and for download

**Literature**

Will be indicated at the beginning of the course

**701-1682-00L Dendroecology**

**Abstract**

The course dendroecology offers theoretical and practical aspects of dendrochronology. The impact of different environmental influences on tree-ring characteristics will be shown. The students learn various methods to date tree rings and they understand how ecological and environmental processes and patterns can be reconstructed using tree rings.

**Objective**

- understand, how wood is configured and how tree-ring structures are formed.
- are able to identify and describe different tree-ring structures.
- understand the theoretical and practical aspects of the dating of tree rings.
- know the effects of different abiotic and biotic environmental influences (climate, site, competition, insects, fire, physical-mechanical influences) on trees and tree rings.
- discover a tool for understanding and reconstructing global change processes.
- learn software to date, standardize and analyze tree rings.
- get hands-on experience based on the demonstration of wood (increment cores, stem discs, wedges), sampling in the field, and measuring and dating of tree rings in the tree-ring lab.
- solve R-based exercises (R tutorial will be provided) and answer questions in Moodle.
- work out an independent research question related to a dendroecological topic and write a short literature review based on scientific papers.
- be enabled to work with such model types on their own
- appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems.

**Content**

- Overview and history of dendrochronology
- Principles of dendrochronology
- Formation and structure of wood and tree rings
- Wood anatomy and intra-seasonal tree-ring growth
- Continuous and discontinuous tree-ring characteristics
- Sampling and measuring of tree rings
- Crossdating methods (visual, skeleton plots, quantitative)
- Detrending and standardization of tree-ring series
- Development of tree-ring chronologies
- Water transport in trees
- Stable isotopes in tree rings
- Climate influences, climate-growth relationships, climate reconstructions
- Reconstruction of forest dynamics (regeneration, growth, competition, mortality)
- Disturbance ecology (fire, insects, blowdown)
- Application of tree-ring research in practice and in interdisciplinary research projects
- Field and lab day (date will be searched together with the students in the beginning of the semester): discussion of different dendroecological questions in the forest; sampling of trees; insight into different tree-ring projects in the lab (Swiss Federal Institute for Forest, Snow and Landscape Research WSL)

**Lecture notes**

Lecture notes (in English) will be handed out in the class.

**Literature**

Literature lists will be handed out in the class.
The students are able to foster Subject-specific Competencies

L. Pellissier assessed

Concepts and Theories fostered


The course covers basic Python language concepts such as data types, control structures and functions. These concepts are then used to foster Environmental Systems Data Science: Machine Learning

A. Baltensweiler

Analytical Competencies

Students will learn the basics of geographic data processing using the Python programming language and ArcGIS Pro (arcpy). They will be able to implement their own geoprocessing scripts for spatial data analysis and modelling. Students will be able to integrate open source libraries into their Python scripts and know how to apply the libraries to geospatial datasets.

The course communicates the basics of the Python programming language and provides a general introduction to the ArcGIS Pro Python scripting framework. It also introduces several Python libraries (pandas, rumpy, scipy, statsmodels, geopandas, rasterio) that greatly extend the capabilities of spatial data analysis and modelling.

Objective

Students will learn the basics of geographic data processing using the Python programming language and ArcGIS Pro (arcpy). They will be able to implement their own geoprocessing scripts for spatial data analysis and modelling. Students will be able to integrate open source libraries into their Python scripts and know how to apply the libraries to geospatial datasets.

Content

The course covers basic Python language concepts such as data types, control structures and functions. These concepts are then used to gain a deeper understanding of ArcGIS Pro’s geoprocessing framework (arcpy). This includes vector data processing functions as well as geoprocessing functions for raster data analysis. It also introduces the use of key Python libraries in conjunction with geospatial datasets.

Literature


Prerequisites / notice

Basic knowledge of ArcGIS is assumed.

Competencies

Subject-specific Competencies fostered

L. Pellissier, C. P. Albouy, M. Volpi

Method-specific Competencies fostered

Prerequisites / notice

Content

The data science workflow

Prepare and clean data

Access and handle (large) datasets

Analysis: data exploratory steps

Analysis: machine learning and computational methods

Evaluate results and analyse uncertainty

Visualisation and communication

Prerequisites / notice

252-0840-02L Anwendungsnahe Programmieren mit Python

401-0624-00L Mathematik IV: Statistik

401-6215-00L Using R for Data Analysis and Graphics (Part I)

401-6217-00L Using R for Data Analysis and Graphics (Part II)

701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

Environmental Systems Data Science: Machine Learning

The students are able to

• select an appropriate model related to a research question and dataset

• describe the steps from data preparation to running and evaluating models

• prepare data for running machine learning with dependent and independent variable

• build and validate regressions and neural network models

• understand convolution and deep learning models

• access online resources to keep up with the latest data science methodology and deepen their understanding

Objective

Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Abstract

The students are able to foster Analytical Competencies

L. Pellissier assessed

Concepts and Theories fostered

Techniques and Technologies fostered

Analytical Competencies fostered

Decision-making fostered

Media and Digital Technologies fostered

Problem-solving fostered

Creative Thinking fostered

Critical Thinking fostered

Method-specific Competencies fostered

Personal Competencies fostered

Prerequisites / notice

Time schedule (total of 90 hours): There will be 12 lectures with each two hours (total of 24 hours presence) as well as a field and lab day (8 hours presence). In addition, the students are expected to put 18 hours into the preparation of the lectures as well as 18 hours for the exercises. 3 hours are reserved for the lab work and 19 hours for the project.

The class language is English, by mutual request only German.

Requirements:

Basics of biology, ecology and forest ecology

Environmental Systems Data Science: Data Processing

The students are able to foster Analytical Competencies

L. Pellissier assessed

Concepts and Theories fostered

Techniques and Technologies fostered

Analytical Competencies fostered

Project Management fostered

Objective

The students are able to foster Analytical Competencies

L. Pellissier assessed

Concepts and Theories fostered

Techniques and Technologies fostered

Analytical Competencies fostered

Problem-solving fostered

Creative Thinking fostered

Critical Thinking fostered

Method-specific Competencies fostered

Personal Competencies fostered

Prerequisites / notice

Basic knowledge of ArcGIS is assumed.

Competencies

Subject-specific Competencies fostered

L. Pellissier, C. P. Albouy, M. Volpi

Method-specific Competencies fostered

Prerequisites / notice

Content

The data science workflow

Prepare and clean data

Access and handle (large) datasets

Analysis: data exploratory steps

Analysis: machine learning and computational methods

Evaluate results and analyse uncertainty

Visualisation and communication

Prerequisites / notice

252-0840-02L Anwendungsnahe Programmieren mit Python

401-0624-00L Mathematik IV: Statistik

401-6215-00L Using R for Data Analysis and Graphics (Part I)

401-6217-00L Using R for Data Analysis and Graphics (Part II)

701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

Environmental Systems Data Science: Machine Learning

The students are able to foster Analytical Competencies

L. Pellissier assessed

Concepts and Theories fostered

Techniques and Technologies fostered

Analytical Competencies fostered

Problem-solving fostered

Creative Thinking fostered

Critical Thinking fostered

Method-specific Competencies fostered

Personal Competencies fostered

Prerequisites / notice

Basic knowledge of ArcGIS is assumed.

Competencies

Subject-specific Competencies fostered

L. Pellissier, C. P. Albouy, M. Volpi

Method-specific Competencies fostered

Prerequisites / notice

Content

The data science workflow

Prepare and clean data

Access and handle (large) datasets

Analysis: data exploratory steps

Analysis: machine learning and computational methods

Evaluate results and analyse uncertainty

Visualisation and communication

Prerequisites / notice

252-0840-02L Anwendungsnahe Programmieren mit Python

401-0624-00L Mathematik IV: Statistik

401-6215-00L Using R for Data Analysis and Graphics (Part I)

401-6217-00L Using R for Data Analysis and Graphics (Part II)

701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

Environmental Systems Data Science: Data Processing

The students are able to foster Analytical Competencies

L. Pellissier assessed

Concepts and Theories fostered

Techniques and Technologies fostered

Analytical Competencies fostered

Problem-solving fostered

Creative Thinking fostered

Critical Thinking fostered

Method-specific Competencies fostered

Personal Competencies fostered

Prerequisites / notice

Basic knowledge of ArcGIS is assumed.

Competencies

Subject-specific Competencies fostered

L. Pellissier, C. P. Albouy, M. Volpi

Method-specific Competencies fostered

Prerequisites / notice

Content

The data science workflow

Prepare and clean data

Access and handle (large) datasets

Analysis: data exploratory steps

Analysis: machine learning and computational methods

Evaluate results and analyse uncertainty

Visualisation and communication

Prerequisites / notice

252-0840-02L Anwendungsnahe Programmieren mit Python

401-0624-00L Mathematik IV: Statistik

401-6215-00L Using R for Data Analysis and Graphics (Part I)

401-6217-00L Using R for Data Analysis and Graphics (Part II)

701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

Environmental Systems Data Science: Machine Learning

The students are able to foster Analytical Competencies

L. Pellissier assessed

Concepts and Theories fostered

Techniques and Technologies fostered

Analytical Competencies fostered

Problem-solving fostered

Creative Thinking fostered

Critical Thinking fostered

Method-specific Competencies fostered

Personal Competencies fostered

Prerequisites / notice

Basic knowledge of ArcGIS is assumed.
Content

- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature

Building on existing data science resources

Prerequisites / notice

Math IV, VI (Statistics); R, Python; ESDS I

401-0627-00L Smoothing and Nonparametric Regression with Examples

Abstract

Starting with an overview of selected results from parametric inference, kernel smoothing will be introduced along with some asymptotic theory, optimal bandwidth selection, data driven algorithms and some special topics. Selected numerical examples will be used for motivation. The presented methods will also be applicable elsewhere.

Objective

The students will learn about methods of kernel smoothing and application of concepts to data. The aim will be to build sufficient interest in the topic and intuition as well as the ability to implement the methods to various different datasets.

Rough Outline:

- Parametric estimation methods: selection of important results
  o Method of Least squares: regression & diagnostics
- Nonparametric curve estimation
  o Density estimation, Kernel regression, Local polynomials, Bandwidth selection, various theoretical results related to consistency
  o Selection of special topics (as time permits, we will discuss some of the following): rapid change points, mode estimation, partial linear models, probability and quantile curve estimation, etc.
- Applications: potential areas of applications will be discussed such as, change assessment, trend and surface estimation and others.

Lecture notes

Summaries or outlines of some of the lecture material may be communicated to registered students by Email at irregular intervals.

Note: These summaries/outlines will tend to be brief, likely to be incomplete & may have typos. Only in-class lessons will contain complete information.

Literature

References:

- Statistical Inference, by S.D. Silvey, Chapman & Hall.
- Density Estimation, by B.W. Silverman, Chapman and Hall.
- Nonparametric Simple Regression, by J. Fox, Sage Publications.

Additional references will be given out in the lectures.

Prerequisites / notice

Prerequisites: A background in Linear Algebra, Calculus, Probability & Statistical Inference including Estimation and Testing.

Competencies

- Subject-specific Competencies
  Concepts and Theories: assessed
  Techniques and Technologies: assessed
- Method-specific Competencies
  Analytical Competencies: assessed
  Decision-making: assessed
  Media and Digital Technologies: fostered
  Problem-solving: assessed
- Social Competencies
  Communication: fostered
- Personal Competencies
  Adaptability and Flexibility: fostered
  Creative Thinking: assessed
  Critical Thinking: assessed
  Integrity and Work Ethics: fostered
  Self-awareness and Self-reflection: fostered
  Self-direction and Self-management: fostered

Colloquium

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<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>701-1691-00L</td>
<td>Colloquium Forest and Landscape Management</td>
<td>Z</td>
<td>0</td>
<td>1.5K</td>
<td>H. Bugmann</td>
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</tbody>
</table>

Abstract

This course is geared towards outreach and dissemination of research results to Swiss forest practitioners.

Objective

Exchange platform between forest science and forest practitioners, geared towards Swiss stakeholders

Competencies

- Subject-specific Competencies
  Concepts and Theories: fostered
  Techniques and Technologies: fostered
- Method-specific Competencies
  Analytical Competencies: fostered
  Decision-making: fostered
  Media and Digital Technologies: fostered
  Problem-solving: fostered
- Social Competencies
  Communication: fostered
- Personal Competencies
  Creative Thinking: fostered
  Critical Thinking: fostered

Major in Human Health, Nutrition and Environment

Public Health
The module Public Health is compulsory for all students in the major Human Health, Nutrition and Environment.

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<tr>
<th>Number</th>
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<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Puhan, R. Heusser</td>
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<td>752-6151-00L</td>
<td>Public Health Concepts</td>
<td>W</td>
<td>3 credits</td>
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<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
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<td>752-6101-00L</td>
<td>Nutrition and Chronic Disease</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>F. von Meyenn, M. Andersson</td>
</tr>
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</table>

**Objective**

After this course students:
- revised Linear Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions

Content

This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both, part one and two will include the following topics: exploratory data analysis, model fitting, model "selection", residual diagnostics, model validation and results interpretation. Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analyzing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

**Comptencies**

Subject-specific Competencies
- Concepts and Theories
  - assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - assessed
- Problem-solving
  - fostered
- Project Management
  - fostered

Social Competencies
- Communication
  - fostered
- Cooperation and Teamwork
  - fostered

Personal Competencies
- Creative Thinking
  - fostered
- Critical Thinking
  - assessed

**Objective**

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

**Comptencies**

Subject-specific Competencies
- Concepts and Theories
  - assessed
- Analytical Competencies
  - assessed
- Decision-making
  - assessed
- Problem-solving
  - fostered
- Project Management
  - fostered

Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - assessed

Social Competencies
- Communication
  - fostered
- Cooperation and Teamwork
  - fostered

Personal Competencies
- Creative Thinking
  - fostered
- Critical Thinking
  - assessed

**Objective**

After this course students:
- can interpret the results of such an analysis and draw valid "biological" conclusions

Content

This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both, part one and two will include the following topics: exploratory data analysis, model fitting, model "selection", residual diagnostics, model validation and results interpretation. Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analyzing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

**Comptencies**

Subject-specific Competencies
- Concepts and Theories
  - assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - assessed
- Problem-solving
  - fostered

Social Competencies
- Communication
  - fostered
- Customer Orientation
  - assessed
- Sensitivity to Diversity
  - assessed

Personal Competencies
- Critical Thinking
  - assessed

**Objective**

Students will be able...
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

Content

Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition).

**Comptencies**

Subject-specific Competencies
- Concepts and Theories
  - assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - assessed

Social Competencies
- Communication
  - fostered
- Customer Orientation
  - assessed
- Sensitivity to Diversity
  - assessed

Personal Competencies
- Critical Thinking
  - assessed

**Objective**

Students will be able...
- to explain heuristic influence of consumer behavior in food domain
- to explain the consumer led food product development
- to summarise how consumers perceive the environmental impact and the healthiness of foods
- to assess the cultural, the environmental and the food policy impact on consumer behavior
- to explain psychological factors influencing eating behavior

Content

This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products.

**Comptencies**

Subject-specific Competencies
- Concepts and Theories
  - assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - assessed
- Problem-solving
  - assessed

Social Competencies
- Communication
  - fostered
- Customer Orientation
  - assessed
- Sensitivity to Diversity
  - assessed

Personal Competencies
- Critical Thinking
  - assessed
Abstract

To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Objective

To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Content

The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Lecture notes

There is no script. PowerPoint presentations will be made available on-line to students.

Literature

To be provided by the individual lecturers, at their discretion.

Prerequisites / notice

No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

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<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
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<tr>
<td>Abstract</td>
<td>Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.</td>
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<tr>
<td>Objective</td>
<td>This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.</td>
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<tr>
<td>Content</td>
<td>A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.</td>
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<tr>
<td>Literature</td>
<td>Publications and class notes can be downloaded from a web page announced during the lecture.</td>
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<tr>
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<td>Social Competencies</td>
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<td>701-1471-00L</td>
<td>Ecological Parasitology ■</td>
<td>W</td>
<td>3 credits</td>
<td>1V+1P</td>
<td>F. Feijen, J. Jokela, C. Vorburger</td>
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<tr>
<td>Notice</td>
<td>Does not take place this semester. Does not take place this semester.</td>
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Autumn Semester 2024
The course will not take place fall semester 2024.

Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

### Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

### Content
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria).

Practical exercises:
1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).
2. Examination of parasites in amphipods (identification and examination of effects on hosts).
3. Examination of parasitoids of aphids.

Prerequisites / notice
The three practicals will take place at the 03.10.2023, the 17.10.2023 and the 07.11.2023 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

### Competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered
- Negotiation: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed

### 701-1703-00L Evolutionary Medicine for Infectious Diseases

**Abstract**
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

**Objective**
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

**Content**
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

**Literature**
The focus is on primary literature, but for some parts the following text books provide good background information:
- Schmid Hempel 2011 Evolutionary Parasitology
- Stearns & Medzhitov 2016 Evolutionary Medicine

**Prerequisites / notice**
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Problem-solving: fostered
- Project Management: fostered

**Social Competencies**
- Communication: fostered
- Cooperation and Teamwork: fostered
- Self-presentation and Social Influence: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Critical Thinking: assessed

### 551-0223-00L Immunology III

**Abstract**
This course provides a detailed understanding of:
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.
Objective Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NK T), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581

Prerequisites / notice
Immunology I and II recommended but not compulsory

752-4009-00L Molecular Biology of Foodborne Pathogens W 3 credits 2V M. Loessner, A. Harms, M. Schuppler, E. Slack

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

Semester Paper and Seminar
The compulsory course 701-1701-00L Human Health, Nutrition and Environment: Term Paper is offered in the autumn semester only.

Number Title Type ECTS Hours Lecturers

Abstract
Writing of a review paper of scientific quality on a topic in the domain of Human Health, Nutrition and Environment based on critical evaluation of scientific literature.

Objective
- Acquisition of knowledge in the field of the review paper
- Assessment of original literature as well as synthesis and analysis of the findings
- Practising of academic writing in English
- Giving an oral presentation with discussion on the topic of the review paper

Content
Topics are offered in the domains of the major Human Health, Nutrition and Environment covering 'Public Health', 'Infectious Diseases', 'Nutrition and Health' and 'Environment and Health'.

Lecture notes
Guidelines will be handed out in the beginning.

Competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
Method-specific Competencies
- Analytical Competencies
- Decision-making
Social Competencies
- Communication
Personal Competencies
- Creative Thinking

Electives
Number Title Type ECTS Hours Lecturers
701-3001-00L Environmental Systems Data Science: Data Processing W 2 credits 2G L. Pellissier, C. P. Albouy, M. Volpi
Abstract

Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods independently or in further courses.

Objective

The students are able to

● frame a data science problem and build a hypothesis
● describe the steps of a typical data science project workflow
● conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
● critically think about the limits and implications of a method
● visualise data and results throughout the workflow
● access online resources to keep up with the latest data science methodology and deepen their understanding

Content

● The data science workflow
● Access and handle (large) datasets
● Prepare and clean data
● Analysis: data exploratory steps
● Analysis: machine learning and computational methods
● Evaluate results and analyse uncertainty
● Visualisation and communication

Prerequisites / notice

252-0640-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt Naturwissenschaften

701-3003-00L Environmental Systems Data Science: Machine Learning

Abstract

Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods independently or in further courses.

Objective

The students are able to

• select an appropriate model related to a research question and dataset
• describe the steps from data preparation to running and evaluating models
• prepare data for running machine learning with dependent and independent variable
• build and validate regressions and neural network models
• understand convolution and deep learning models
• access online resources to keep up with the latest data science methodology and deepen their understanding

Content

• The data science workflow
• Data preparation for running and validating machine learning models
• Get to know machine learning approaches including regression, random forest and neural network
• Model complexity and hyperparameters
• Model parameterization and loss
• Model evaluations and uncertainty
• Deep learning with convolutions

Literature

Building on existing data science resources

Prerequisites / notice

Math IV, VI (Statistics); R, Python; ESDS I

► Minors

►► Minor in Sustainable Energy Use

Number Title Type ECTS Hours Lecturers
701-0967-00L Project Development in Renewable Energies W 2 credits 2G R. Rechsteiner, A. Appenzeller

Abstract

The focus is on the implementation of projects:
- photovoltaics
- wind energy
- hydropower
You will learn about new business models, including storage and sector coupling, discuss framework conditions, economic efficiency, security of supply, market organization and business risks. Guidance from experts with many years of political and project experience.

Objective

You will receive a practice-oriented introduction to the regulatory and economic requirements for renewable energy projects.

You will be familiar with the options for integrating fluctuating energy production in an environment of volatile prices.

You will be familiar with the opportunities and risks and strategies for economic security.

Content

Detailed program
https://www.rechsteiner-basel.ch/lehrmittel?no_cache=1#c273

Lecture notes
PPT presentation will be distributed (in German)
Literatur

- Rudolf Rechsteiner: Die Energiewende im Wartesaal, Verlag Zocher & Peter, Zürich 2021 (wird als PDF abgegeben)
- Renewable 2024 Global Status Report (global overview)
- IEA PVPS: TRENDS IN PHOTOVOLTAIC APPLICATIONS
- Snapshots 2024 http://www.iea-pvps.org

Prerequisites / notice

- Study plan, course and Prerequisites
- Decision-making
- Problem-solving
- Project Management

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Self-presentation and Social Influence
- Sensitivity to Diversity

- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

- Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Self-presentation and Social Influence
- Sensitivity to Diversity

- Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Competencies

- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

- Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

- Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

- Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Course: Power Market I - Portfolio and Risk Management

- Credit points: 6
- Prerequisites / notice: Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

- Objective: The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

- Content: From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

- Literature: Will be identified based on the chosen topic.

- Competencies:
  - Subject-specific Competencies: fostered
  - Method-specific Competencies: fostered
  - Social Competencies: fostered
  - Personal Competencies: fostered
Objective

Content
1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX
2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions
3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   3.7. Risk Management 3 (enterprise wide)
4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

Lecture notes
Handouts of the lecture

Prerequisites / notice
Case studies and ML exercise for Power Market can give bonus points for the exam. Guest speakers for specific topics.

Competencies
Concepts and Theories assessed
- Decision-making
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed
- Communication fostered
- Cooperation and Teamwork fostered
- Adaptable and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking fostered

Minor in Physical Glaciology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0289-00L</td>
<td>Applied Glaciology</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>D. Farinotti, A. Bauder, M. Werder</td>
</tr>
</tbody>
</table>

Abstract
The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

Objective
- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

Content
The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Lecture notes
Digital lecture handouts will be distributed prior to each class.

Literature
Links to relevant literature will be provided during the classes.

Prerequisites / notice
Completed BSc studies. Basic knowledge in computer scripting in any language (e.g. Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.
Seminar in Glaciology

Abstract
Introduction to classic and modern literature of research in Glaciology. Active participation is expected and participants are mentored by PhD students of Glaciology.

Objective
In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

Content
Selected topics of scientific research in Glaciology

Lecture notes
Copies/pdf of scientific papers will be distributed during the course (moodle interface)

Prerequisites / notice
Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:
- 651-3561-00L Kryosphäre
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers

Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)

Abstract
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO815

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline_s.html

Objective
This course introduces quantitative approaches and models to processes of the cryosphere in high mountain areas. The main focus are dynamic and thermal processes related to glaciers and permafrost. During the course, simple simple mathematical and numerical models will be used to investigate ground temperature profiles as well as glacier evolution and dynamics in relation to climate.

Content
This course combines lectures providing the background on the physical processes and methods with computer practicals in which quantitative methods are applied to glaciers and permafrost processes. These lectures and practicals run as 2-hour blocks per week and are combined with group and individual exercises. Topics indicative for the content of this course are:

- Heat flow processes in the ground and in glaciers, and their solution with numerical models.
- Glacier dynamics and evolution in relation to climate change.
- Simple and reduced mathematical models for glaciers flow.
- Numerical models for glacier dynamics.

For the modeling and project parts of the course, programs written in the Python programming language are used. Prior Python or programming knowledge is not necessary, and introductory tutorials are given.

The course starts with lectures introducing the basic concepts of the different topics. The main focus lies on extensive computer practicals in which the related quantitative methods and models are applied and explored. Extensive group work on a topic of choice, using the quantitative models, will give a deep understanding how computer models are used in applied science.

Physics of Glaciers

Abstract
Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismicity, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.
Objective
After the course the students are able to understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

Content
The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Lecture notes
Will be provided on Moodle

Literature
A list of relevant literature is available on Moodle

Prerequisites / notice
High-school mathematics and physics knowledge required.

佣金
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Self-presentation and Social Influence fostered

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered

Minor in Catchment Management and Natural Hazards

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0565-00L</td>
<td>Principles of Natural Hazard Management</td>
<td>W</td>
<td>3 credits</td>
<td>4G</td>
<td>A. Ringenbach</td>
</tr>
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</table>

Abstract
This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts and a field trip.

Objective
By the end of the course, students will be able to:

- explain the main natural hazards, their processes and their importance in different contexts,
- describe the likelihood, risk, and consequences of natural hazards and their management options,
- identify and discuss the development of natural hazards in the context of climate change.

Literature
will be distributed and available on Moodle

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Problem-solving assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>101-1250-00L</td>
<td>Transport Processes in Torrents</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>I. Schalko</td>
</tr>
</tbody>
</table>

Abstract
This course focuses on the various transport processes in torrents. This includes discharge, bedload, debris flow, and large wood. Differences between transport processes in rivers versus torrents will be discussed. Special focus will be put on the (1) analysis of the interaction between the transport processes (cascading processes) and the (2) design of countermeasures.

Objective
At the end of the course, the students will be able to:

1. Describe the different transport processes in torrents, such as flow discharge or bedload transport,
2. discuss how cascading processes affect the resulting natural hazard, and
3. derive solutions for a sustainable hazard management.

Content
The first part of the lecture introduces the different transport processes in torrents such as discharge, bedload, debris flow, and large wood. This will include methods to determine and calculate the discharge, characterize debris flow, and quantify wood load.

In the second part of the lecture, special focus will be put on the cascading effects (what happens if multiple transport processes occur at once) and their implications on the resulting natural hazards.

The last part of the lecture focuses on the design of countermeasures such as check dams and will include examples from selected catchments in Switzerland.

Lecture notes
Lecture slides can be downloaded via Moodle.

Literature


Prerequisites / notice
Recommended lectures:
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), Hydraulic Engineering (101-0206-00L), River Engineering (101-0258-00L)
<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>fostered</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>fostered</td>
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<table>
<thead>
<tr>
<th>102-0293-00L</th>
<th>Hydrology</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>P. Burlando</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the rainfall-runoff transformation, thereby including flood analysis.</td>
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<tr>
<td>Objective</td>
<td>Know the main features of engineering hydrology. Apply methods to estimate hydrological variables for dimensioning hydraulic structures and managing water resources.</td>
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<tr>
<td>Lecture notes</td>
<td>The lecture notes as well as the lecture presentations and handouts may be downloaded from the website of the Chair of Hydrology and Water Resources Management.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Knowledge of statistics is a prerequisite. The required theoretical background, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows: Elementary data processing; hydrological measurements and data, visualisation (graphical representation and numerical parameters). Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.</td>
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<table>
<thead>
<tr>
<th>651-3525-00L</th>
<th>Introduction to Engineering Geology</th>
<th>W</th>
<th>4 credits</th>
<th>2V+1U</th>
<th>J. Aaron, L. de Palézieux dit Falconnet, M. Ziegler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This introductory course starts from a description of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally, practical aspects of ground engineering, including tunneling and landslide hazards are presented.</td>
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<td>Content</td>
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<tr>
<td>Lecture notes</td>
<td>Written course documentation available on moodle.</td>
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</tbody>
</table>
Literature

https://eth.swisscovery.slsp.ch/permalink/41SLSP_ETH/ishl64/alma99117209929405503

Prerequisites / notice

Lectures held by Prof. J. Aaron will be conducted in English. The lecture slides for these lectures will be available in both German and English. All other lecture material will be provided in German. The exam is held in German.

Students registering for the course confirm having read and accepted the terms and conditions for excursions and field courses of D-EAPS:
https://www.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/studium/exkursionen/AGB_ERDW_Exkursionen_en.pdf

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Personal Competencies
- Critical Thinking fostered

651-4088-03L Physical Geography III (Geomorphology and Glaciology) (University of Zürich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO231
Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cms/services/application/deadlines.html

Abstract

Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufs. Dabei werden einzelne Wasserspeicher (Schnee, -Boden und Grundwasser) und Flüsse zwischen den Speichern (Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.

►► Minor in Forest Engineering and Wood Products

To successfully complete this minor, KPs must be earned for the two required courses:
- 701-1645-00 Forest Operations (autumn semester) and
- 701-1544-00 Forest Access and Transportation (spring semester)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1645-00L</td>
<td>Forest Operations</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>H. Griess, J. Schweier</td>
</tr>
</tbody>
</table>

Abstract

The discipline of Forest operations is constantly challenged to find solutions for unique problems. Each forest site requires specific technological approaches and machinery based on given management goals and ecological and environmental circumstances. Various terrain types and soil conditions, harvesting costs and taking care of the workforce by creating safe working conditions are some of the a Objective

In this course, students will learn to use a wide variety of approaches grounded in the natural sciences, engineering and technology to develop solutions tailored to unique challenges from the field of forest operations. The course is aimed at students who either plan an academic or professional career in the field of forest operations, or who will work at the interface between forest operations and the various related disciplines, such as forest ecosystem management and forestry in the wider sense. After participating in this course students will have acquired foundational knowledge of a wide variety of core elements in the field of forest operations:
- The course will provide students with the ability to describe and differentiate site and stand conditions from an engineering perspective.
- Students will gain an overview and good working knowledge of current technology used in forest operations in Switzerland and around the world.
- Students will acquire the ability to assess the strength and weaknesses of the most commonly used equipment and analyze their suitability for a given set of environmental, economic and social factors.
- Students will be able to combine different types of technology to create an optimal harvesting system for a given task, and assess a given system for its task specific suitability.
- Participants will be able to assess the sustainability and potential short- and long-term impacts of harvesting systems under ecological, economic and social constraints.
Introduction
• Historic overview
• Scope of operation
• Site and stand characteristics

Timber harvesting
• Logging methods
• Felling methods
• Motor-Manual felling methods
  • Felling and processing
• Forest machine structure and function
• Harvester Technology
  • Felling heads
  • Carriers for felling heads
• Bunching
• Mechanical processing
• Loading equipment
• Operating techniques

Primary Transport Systems
• Ground based
  • Common features
  • Skidder
  • Forwarder
  • Loader Forwarder
• Cable yarding
  • Common features
  • Wire rope
  • Cable yarding systems
  • Operating techniques
• Aerial
  • Common features
  • Operating techniques

Winch-Assisted Harvesting Operations
• Harvesting
• Primary transport

Loading Equipment

Secondary transport
• Truck configurations
• Soil compaction and contamination
• Riparian areas

Forest Operations management
• Ergonomics
• Work Safety
• Economic Aspects
• Environmental impact assessment
• Equipment selection

Forest operations across the globe
• New Zealand
• North America
  • British Columbia, Canada
  • South-eastern U.S.A

Specialized equipment for small scale forest operations

Outlook into the future of forest operations

Literature
Published on Moodle

Prerequisites / notice
701-1544-00 Forest Access and Transportation

101-0637-10L Wood Structure and Function W 3 credits 2G I. Burgert, G. von Arx
Abstract
The course Wood structure and function conveys basic knowledge on the microstructure of softwoods and hardwoods as well as general and species-specific relationships between growth processes, wood properties and wood function in the living tree.

Objective
Learning target is a basic understanding of the anatomy of wood and the related impact of endogenous and exogenous factors. The students can learn how to distinguish common central European wood species at the macroscopic and microscopic level. A deeper insight will be given by wood identification exercises for softwood species. Further, the students will gain insight into the relationships between tree growth and wood properties with a specific focus on the wood function in the living tree.

Content
In an introduction to wood anatomy, the general structural features of softwoods and hardwoods will be explained and factors of diversity and variability will be discussed. A specific focus is laid on common central European tree species with relevance in the wood sector, which will be studied in macro- and microstructural investigations. In the following, relationships between wood structure, properties and function in the living tree will be in the focus of the lectures. Topics covered are water transport, trends in wood anatomy within trees, environmental impact on wood anatomy, wood defects and their causes, tools to study wood properties over time, secondary changes in wood, and tree biomechanics.

101-0637-20L Wood processing W 3 credits 2G I. Burgert, S. Koch, M. Schubert
Abstract
The course Wood Processing conveys knowledge on the technological properties of wood and wood-based materials as well as on industrial processes for the fabrication of a vast variety of wood products and covers new developments in the field of digital technologies.

Objective
The learning target is a fundamental understanding of the dominating wood processing chains, which are applied to fabricate common wood products. Students will be introduced to the economic relevance of the renewable resource wood and are trained in its technological properties. The students will learn to identify the relationships between wood species and their properties as well as the suitable wood machining processes to fabricate targeted wood products. Finally, the digital transformation process, which will affect all sectors of the wood industry with an impact on the entire value chain and business models will be covered. It will be illustrated how production processes can become more flexible, efficient and less resource-demanding.
Water limitation is a primary constraint on plant growth and terrestrial fluxes worldwide. In this course, the principles of water flow in soil are assessed.

Subject-specific Competencies

Media and Digital Technologies

Lecture notes; selection of articles

Soil-Plant Water Relations

fostered

Techniques and Technologies

assessed

Part 1 - Lectures

Soil-Plant Water Relations: Principles of soil water retention and soil water flow; Soil hydraulic properties.

Week 2: Soil water relations; Principles of soil water retention and soil water flow; Soil hydraulic properties.

Week 3: Root water uptake; soil hydraulic constraints on transpiration

Week 4: Rhizosphere processes and properties; root-soil contact; root hairs; mycorrhiza; rhizodeposition.

Week 5: Water flow in roots and xylem; root anatomy, architecture and plasticity; cavitation.

Week 6: Transpiration; Vapor Pressure Deficit; Photosynthesis; Stomatal regulation.

Week 7: Soil-plant-atmospheric continuum; Below- and above-ground feedbacks; Soil and atmospheric drivers of transpiration losses.

Part 2 - Seminar

Week 8: Plant response to drought and consequences for agriculture and forests. Open questions and introduction to seminar topics.

Week 9: Class work - preparation of the presentations/Debate

Week 10: Class work - preparation of the presentations/Debate

Week 11: Seminar/Debate (presentations)

Week 12: Seminar/Debate (presentations)

Week 13: Seminar/Debate (presentations)

Week 14: Feedback, Summary, Conclusion

Political Ecology of Food and Agriculture

Number of participants limited to 25

A motivational application is required:
- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Questions regarding the application to johanna.jacobi@usi.ethz.ch.

In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

Objective

- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

Content

We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.
Abstract
In politics, society, and science, it can seem that the values and practices of agricultural production and environmental protection are in conflict. This tension is often described as "protection versus use" of natural resources. We will explore ways to move beyond the apparent conflict. We will apply this learning to field trips and transdisciplinary projects.

Objective
Students are able to:
- Define different kinds and categories of values.
- Relate value concepts to their own studies, life, and experiences through reflective journaling.
- Infer the underlying values in a text or policy about agri-environmental topics.
- Collaboratively develop a transdisciplinary project for an agri-environmental case study from the field trips.

Content
The course consists of interactive seminars alongside fieldtrips to farms that have found innovative solutions to balancing protection and production.

Seminars will cover topics such as the relationship between values and behavior and how people perceive value trade-offs. We will also discuss environmental ethics, environmental valuation and its critiques, the interplay of facts and values in agri-environmental decision-making, cultural ecosystem services, and relational values.

This class requires active participation. Learning is based on in-class activities, group work and fieldtrips.
The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

Lecture notes
Handouts stehen online.

Literature

Prerequisites / notice
This course is based on basics of plant identification and plant physiology. It is the basis for the courses Plant Production, Part Forage Production and Grassland Systems.

Competencies
Subject-specific Competencies
Concepts and Theories
Method-specific Competencies
Analytical Competencies
Media and Digital Technologies
Problem-solving
Personal Competencies
Critical Thinking

751-4003-01L Current Topics in Grassland Sciences (autumn)

Objective
Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.

Content
Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as by doctoral and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

Lecture notes
none

Prerequisites / notice
Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.

Competencies
Subject-specific Competencies
Concepts and Theories
Method-specific Competencies
Analytical Competencies
Social Competencies
Communication
Personal Competencies
Critical Thinking

751-4104-00L Alternative Crops

Objective
During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

Content
Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

Competencies
Subject-specific Competencies
Concepts and Theories
Method-specific Competencies
Media and Digital Technologies
Problem-solving
Social Competencies
Cooperation and Teamwork
Self-presentation and Social Influence
Portable Competencies
Creative Thinking

751-4704-00L Weed Science

Objective
Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops.

Content
Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops. Accordingly, this knowledge will be imparted during the course and will be required to understand the mechanisms of integrated weed control strategies.

751-5003-00L Sustainable Agroecosystems II

Objective
(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).
The course will address a wide range of agricultural and food system challenges (e.g. food security, climate crisis, soil degradation, etc.) in both temperate and tropical contexts. In class we will address topics like building food system resilience through innovative measures, improving soil fertility management or understanding the effects of agroforestry systems. Case studies from the on-going research in the Sustainable Agroecosystems Group (sae.ethz.ch) will be presented, covering different scales (e.g. food value-chains, farm dynamics and soil management).

The course is complemented by practical group work conducted with the CSA MehAlsGmeus in Zurich on Measuring and monitoring Agroecological performance. Students will gain an overview on institutions and actors’ roles in the field of sustainable agricultural development. Throughout the group work, students will learn to engage directly with various stakeholders, monitor agroecological transition and communicate their research to a wider audience. Ultimately, this class should provide an overview on methods, tools, innovations and platforms that support a sustainable food transformation.


Prerequisites / notice
Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.

Literature

Competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Decision-making: fostered
  - Problem-solving: assessed
  - Project Management: fostered

- Social Competencies
  - Communication: fostered
  - Cooperation and Teamwork: assessed
  - Self-presentation and Social Influence: fostered
  - Sensitivity to Diversity: fostered

- Personal Competencies
  - Adaptability and Flexibility: fostered
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: fostered
  - Self-awareness and Self-reflection: fostered
  - Self-direction and Self-management: fostered

-resource and environmental economics
- efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy.

- Program Elements:

  - Risk Analysis and Risk Management in Agriculture (751-0423-00L)
  - Resource and Environmental Economics (751-0537-00L)
  - Subject-specific Competencies
    - Concepts and Theories: assessed
    - Analytical Competencies: assessed
    - Techniques and Technologies: assessed

  - Social Competencies
    - Sensitivity to Diversity: fostered
    - Communication: fostered

  - Personal Competencies
    - Adaptability and Flexibility: fostered
    - Critical Thinking: assessed
    - Integrity and Work Ethics: fostered
    - Self-awareness and Self-reflection: fostered

  - W -to develop a better understanding of decision making under uncertainty and risk;
    - gain hands-on experience in risk analysis and management using R
    - to develop an understanding for different sources of risk in agricultural production;
    - to understand the crucial role of subjective perceptions and preferences for risk management decisions;
    - to get an overview on risk management in the agricultural sector, with a particular focus on insurance solutions.

  - R -to gain experience in different approaches to analyze risky decisions;
    - to develop understanding for different sources of risk in agricultural production;
    - to get an overview on risk management in the agricultural sector, with a particular focus on insurance solutions.

  - 3 credits

  - Autumn Semester 2024

  - Education


  - Literature


  - Case studies from the on-going research in the Sustainable Agroecosystems Group (sae.ethz.ch) will be presented, covering different scales (e.g. food value-chains, farm dynamics and soil management).


  - Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.
Content
- Quantification and measurement of risk
- Risk preferences, Expected Utility Theory, Cumulative Prospect Theory
- Production and input use decisions under risk
- Portfolio Theory and Farm Diversification
- Forwards, Futures, Crop Insurance
- Weather Index Insurance and Satellite Imagery
- Empirical Applications using R

Lecture notes
Handouts will be distributed in the lecture and available on the moodle.

Prerequisites / notice
knowledge of basic concepts of probability theory and microeconomics

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

751-0903-00L Microeconomics of the Agriculture and Food Sector
W 3 credits 2V L. Zachmann

Abstract
In dieser Vorlesung werden ökonomische Charakteristika des Agrar- und Lebensmittelsektors herausgearbeitet und anderen Sektoren gegenübergestellt. Fokus ist dabei Lebensmittelindustrie in der Schweiz und in der EU. Es werden mikroökonomische Zusammenhänge, insbesondere zur Preis- und Mengenbildung in verschiedenen Wettbewerbsmodellen, am Fallbeispiel des Agrar- und Ernährungssektors vermittelt.

Objective

Content
- Der Agrar- und Lebensmittelsektor in der EU und der Schweiz
- Preiselastizitäten von Angebot und Nachfrage im Ernährungssektor
- Gewinnmaximierung
- Grundlagen der Spieltheorie
- Monopol / Monopolistischer Wettbewerb
- Oligopol (Stackelberg, Cournot, Bertrand)
- Monopson
- Produktdifferenzierung
- Preisdiskriminierung
- Kartelle

Literature

Prerequisites / notice
Empfohlene Vorkenntnisse:
- Grundkenntnisse der Ökonomie/Agrarökonomie
- Vorlesung Einführung in die Mikroökonomie

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies
Problem-solving assessed
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Sensitivity to Diversity fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

751-1311-00L Introduction to Agricultural Management
W 2 credits 2V R. Finger

Abstract
Vermittlung von betriebswirtschaftlichen Grundlagenwissen und Analyse- und Planungsinstrumenten mit Anwendung auf Unternehmen der Agrar- und Ernährungswirtschaft

Objective
Teilnehmer des Kurses sollen am Ende der Vorlesung i) grundlegende Unternehmensentscheide strukturieren und analysieren können, ii) verschiedene Analyse- und Planungsinstrumente auf Fragestellungen der Produktionsplanung, Investition und Finanzierung an Beispielen anwenden zu können, iii) verschiedene Werkzeuge zur unternehmerischen Entscheidungsunterstützung anwenden können und iv) die Spezifika von Unternehmen in der Agrar- und Ernährungswirtschaft kennen.

Content
Die Vorlesung geht auf folgende Inhalte, mit spezifischen Anwendungen im Agrar- und Ernährungssektors ein:

- Grundlagen und Ziele unternehmerischen Entscheidens
- Kosten und Leistungsrechnung
- Produktionstheorie
- Produktionsprogrammplanung
- Investitionsplanung und Finanzierung
- Entscheidungen unter Unsicherheit und Risikomanagement

Literature

Lecture notes
Vorlesungsunterlagen werden im Laufe des Semesters zur Verfügung gestellt
Competencies | Subject-specific Competencies | Concepts and Theories | assessed
---|---|---|---
| Techniques and Technologies | assessed
| Method-specific Competencies | Analytical Competencies | assessed
| Decision-making | assessed
| Media and Digital Technologies | fostered
| Problem-solving | assessed
| Social Competencies | Communication | fostered
| Sensitivity to Diversity | fostered
| Personal Competencies | Adaptability and Flexibility | fostered
| Creative Thinking | assessed
| Critical Thinking | assessed
| Integrity and Work Ethics | fostered
| Self-awareness and Self-reflection | fostered
| Self-direction and Self-management | fostered

751-1573-00L  Dynamic Simulation in Agricultural and Regional Economics  W  3 credits  2V  B. Kopainsky

Abstract
In this class, students learn the basics of system dynamics and its application to agricultural and regional economic questions. In the second half of the class, students develop their own simulation model, with which they evaluate potential interventions for improving the economic as well as the ecological sustainability of food systems.

Objective
- Students learn the basic theory and practice of dynamic simulation
- Students can develop, analyze and extend a dynamic simulation model and interpret its results.
- By applying the developed simulation model, students gain insights into food system issues. They also learn to recognize the benefits and pitfalls of dynamic simulation, both from a theoretical and an applied perspective.

Lecture notes
slides (will be provided during the class)

Literature
articles and papers (will be provided during the class)

751-2103-00L  Socioeconomics of Agriculture  W  2 credits  2V  S. Mann

Abstract
The main part of this lecture will examine constellations where hierarchies, markets or cooperation have been observed and described in the agricultural sector. On a more aggregated level, different agricultural systems will be evaluated in terms of main socioeconomic parameters like social capital or perceptions.

Objective
Students should be able to describe the dynamics of hierarchies, markets and cooperation in an agricultural context.

Content
Introduction to Sociology
Introduction to Socioeconomics
Agricultural Administration: Path dependencies and efficiency issues
Power in the Chain
The farming family
Occupational Choices
Market segregation
The issue of meat demand
Common Resource Management in Alpine Farming
Agricultural Cooperatives
Societal perceptions of agriculture
Perceptions of farming from within
Varieties of agricultural systems and policies

Lecture notes

Literature
see script

Prerequisites / notice
Basic economic knowledge is expected.

751-2105-00L  Political Ecology of Food and Agriculture  W  3 credits  2G  J. Jacobi

Number of participants limited to 25
A motivational application is required:
- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Questions regarding the application to johanna.jacobi@usys.ethz.ch.

Abstract
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

Objective
- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

Content
We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools.
For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.
The image contains a document page with lecture notes and information about various courses. The lecture notes cover topics such as political ecology, ontologies, epistemologies, green revolution, industrial agriculture, agroecology, water management, climate justice, food systems, conservation, deforestation, pandemics, syndemics, and more.

The courses are scheduled from 20.9.2024 to 20.12.2024, with topics ranging from introduction to political ecology to evaluation of agricultural policies. The literature list is provided on Moodle when the course starts.

The competencies section lists various competencies such as subject-specific and method-specific competencies, including decision-making, problem-solving, cooperation and teamwork, leadership, responsibility, negotiation, adaptability, flexibility, creative thinking, critical thinking, integrity, work ethics, self-awareness, self-reflection, and self-direction.

Electives are also mentioned, including additional electives for the Autumn Semester 2024. The number 751-2903-00L Evaluation of Agricultural Policies is highlighted, with a focus on understanding and applying the principles of scientific based evaluations of agricultural policies.
Content

The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is not a scientific paper) to identify the key points for discussion.

Thereafter, in each week a text (typically a chapter from a book or a paper) considered to be seminal or foundational will be assigned by a course lecturer. The lecturer will introduce the selected text with a brief background of the historical and cultural context in which it was written, with some additional biographical information about the author. He/she will also briefly explain the justification for selecting the particular text.

The students will read the text, with two to four students (depending on class size) being assigned to present it at the next session. Presentation of the text requires the students to prepare by, for example:

- identifying the key points made within the text
- identifying issues of particular personal interest and resonance
- considering the impact of the text at the time of publication, and its importance now
- evaluating the text from the perspective of our current societal and environmental position

Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (6 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

Literature

The specific texts selected for discussion will vary, but examples include:

- Leopold (1949) A Sand County Almanach
- Carson (1962) Silent Spring
- Jared Diamond (2005) Collapse

Discussions might also encompass films or other forms of media and communication about nature.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Media and Digital Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>fostered</td>
<td>fostered</td>
<td>assessed</td>
<td>fostered</td>
</tr>
</tbody>
</table>

Objectives

701-3001-00L Environmental Systems Data Science: Data Processing

- Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Content

- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice

252-0840-02L Anwendungsnahe Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umweltwissenschaften

701-3003-00L Environmental Systems Data Science: Machine Learning

- Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning models.

Objective

- Select an appropriate model related to a research question and dataset
- Describe the steps from data preparation to running and evaluating models
- Prepare data for running machine learning with dependent and independent variable
- Build and validate regressions and neural network models
- Understand convolution and deep learning models
- Access online resources to keep up with the latest data science methodology and deepen their understanding
Autonomous robots are quickly becoming a key player in the transition to precision agriculture. In this course, students will learn theoretical and practical aspects of robotics. Lectures will introduce how robots operate and analyse their application to precision agriculture. In hands-on laboratories, students will apply concepts learned in class on educational robots to simulate a weeding task.

After the course, students will be able to critically examine and select appropriate robotic solutions for agricultural applications. The learning objectives of the course are: (i) illustrate the principle of operation of the main components of a robotic system, (ii) analyse how the different robotic components are integrated and contribute to the functioning of a robotic system, and (iii) solve problems in the field of agriculture using robotic principles.

Robots are becoming a key technology in the transition to smart farming and in supporting the agricultural needs of the 21st century. For example, robots enable site-specific fertilization, automated weeding, or livestock herding. The course gives an overview of robotic systems, beginning with their fundamental components (e.g., sensors, actuators, locomotion strategies) and gradually scaling up to the system level, illustrating the concepts of perception, robot control, obstacle avoidance and navigation. Exercises performed with an educational robot (Thymio) will complement the theoretical lectures providing a hands-on practical experience of the challenges of using these machines.

During the course, students will gradually apply the theoretical and practical knowledge they are learning. To this end, students will work in teams to develop a robotic solution for an agricultural task of their choice. Students will learn to translate the task into meaningful requirements for a robotic system and critically select the most appropriate components to achieve the required robotic functions. Students will periodically present and discuss the development of this "robot design" exercise during presentations and in a journal report.

The course gives an overview of robotic systems, beginning with their fundamental components (e.g., sensors, actuators, locomotion strategies) and gradually scaling up to the system level, illustrating the concepts of perception, robot control, obstacle avoidance and navigation. Exercises performed with an educational robot (Thymio) will complement the theoretical lectures providing a hands-on practical experience of the challenges of using these machines.

During the course, students will gradually apply the theoretical and practical knowledge they are learning. To this end, students will work in teams to develop a robotic solution for an agricultural task of their choice. Students will learn to translate the task into meaningful requirements for a robotic system and critically select the most appropriate components to achieve the required robotic functions. Students will periodically present and discuss the development of this "robot design" exercise during presentations and in a journal report.

No mandatory prerequisites, but it is preferable that students have a basic knowledge of computer programming.

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<td>Class size limitation to 30 students.</td>
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**Course Catalogue of ETH Zurich**

**Professional Internship**

**Number**  701-1001-00L

**Title**  Professional Internship

**Type**  O

**ECTS**  30 credits

**Hours**  30

**Lecturers**  J. Schlosser

In the internship outside of ETH Zürich, the students in Environmental Sciences learn about how environmental issues are handled professionally through their own practical work and by applying the knowledge they acquired. They will analyse complex environmental problems on scientific, technical and social levels and develop solutions in conjunction with social actors.

Registration and recognition of professional internship via https://www.lehrbetrieb.ethz.ch/praxis

No registration in myStudies required. For more information consult the Moodle-course Berufspraxis

Objective

During the internship, students will learn how to professionally handle environmental issues from the technical-scientific, planning, administrative, and/or advisory perspective through their own practical experiences. They should apply the knowledge acquired from their studies. Furthermore, students will deepen their understanding in terms of development and implementation of environmental-friendly solutions in an everyday work-routine. Through this experience, they will develop important professional competence. Moreover, the internship will show them possible professional fields and establish valuable contacts for starting their careers in the future.

Content

The professional internship is a compulsory part of the Master’s degree programme and requires that each student complete 18 weeks outside of ETH Zurich. It can be completed in Switzerland or abroad. The students choose the position of the internship themselves. The position needs to fulfill the aims and requirements of the compulsory internship.

Job positions for environmental scientists are available in the following areas: environmental consulting firms, engineering and planning offices, clean-tech companies, industrial and service companies, federal administration, administration of cantons and municipalities, organizations and associations as well as companies operating in education, higher education, and media in relation to environmental and sustainable themes. Generally, the internship is performed outside of universities, colleges and research institutes.

Lecture notes

Further support is provided by the company catalogue with companies in Switzerland and abroad that offer internships according to possibilities or where professional internships have taken place so far: https://www.usys.ethz.ch/pa-internship-envsc


Further information and support online https://moodle-app2.let.ethz.ch/course/view.php?id=15228

Competencies

Subject-specific Competencies

Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies

Analytical Competencies fostered
Problem-solving fostered
Project Management fostered

Social Competencies

Communication fostered
Cooperation and Teamwork fostered

Personal Competencies

Adaptability and Flexibility fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1002-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract

The study programme is completed by a Master’s thesis. The Master’s thesis is an independent, scientific work. A topic within the field of specialization is chosen. It lasts 6 months.

Objective

This component is designed to enable the students to explore how the course content can be applied to an actual scientific problem. The thesis also provides an opportunity for the students to exercise initiative and to demonstrate that they are capable of working independently and in a scientifically structured manner.

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Problem-solving assessed
Project Management assessed

Social Competencies

Communication assessed

Personal Competencies

Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management assessed

Course Units for Additional Admission Requirements

The courses below are only available for Master students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>351-1158-AAL</td>
<td>Principles of Economics</td>
<td>E-</td>
<td>3 credits</td>
<td>6R</td>
<td>U. Renold, T. Bolli, P. McDonald, F. Pusterla, A. Zubovic</td>
</tr>
</tbody>
</table>

Abstract

Students understand basic microeconomics and macroeconomics problems and theories. They are able to argue along economic principles and to judge policy measures.
Objective
Upon successful completion of the course, you will be able to:
- Describe the basic microeconomic and macroeconomic problems and theories.
- Make economic arguments to a given topic.
- Evaluate economic measures.

Content
Households, firms, supply and demand: How are household preferences and consumption behavior formed? How does a household react to price changes? How are goods prices formed? At what prices are firms willing to offer goods? How do we make economic decisions?
Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can governments influence the market?
Market failure: What happens when prices give wrong signals?
Labor market: How do supply and demand work in the labor market? What influences unemployment?
National Accounts: How big is the Swiss economy?
Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?
Money and inflation: What exactly is money? How does money creation work, and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society.

Literature

Competencies

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<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
<td>Personal Competencies</td>
<td>Self-direction and Self-management</td>
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<td>assessed</td>
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</table>

406-0062-AAL Physics I
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

Content

Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Wiley-VCH Verlag, 2002
4th edition 2022

Competencies

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<th>Competencies</th>
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<th>Concepts and Theories</th>
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<tr>
<td>Personal Competencies</td>
<td>Self-direction and Self-management</td>
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406-0063-AAL Physics II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the "way of thinking" and the methodology in Physics. The Chapters treated are Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

Content

Chapters:

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2: Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003
4th edition 2022

Competencies

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<th>Concepts and Theories</th>
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406-0064-AAL Physics I and II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2544 of 2667
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter. The student should acquire an overview over the basic concepts used in mechanics, in the theory of heat and electricity.

Content
Book:

Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6), 15 (without 15-3, 15-5, 15-7, 15-9, 15-10, 15-11), 17 (without 17-5, 17-10), 18 (without 18-5, 18-6, 18-7), 19, 20 (without 20-7, 20-8, 20-9, 20-10, 20-11), 21 (without 21-12), 23, 25 (without 25-9, 25-10), 26 (without 26-4, 26-5, 26-7), 27, 28 (without 28-4, 28-5, 28-8, 28-9, 28-10), 29 (without 29-5, 29-8), 32 (without 32-8), 33 (without 33-4, 33-5, 33-9, 33-10), 34 (without 34-4, 34-6, 34-7), 35 (without 35-2, 35-3, 35-9, 35-11, 35-12, 35-15).

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Wiley-VCH Verlag, 2002,
4th edition 2022

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003
4th edition 2022

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered
Problem-solving assessed
Self-direction and Self-management fostered

406-0251-AAL Mathematics I
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

Objective
Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of these courses.

Content
1. Linear Algebra and Complex Numbers:
   systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

2. Single-Variable Calculus:
   review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

3. Ordinary Differential Equations:
   separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

   - Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

Prerequisites / notice
familiarity with the basic notions from Calculus, in particular those of function, derivative and integral.

Schedule and location of the assistance hours (Mathe-Lab) may be found on the Moodle webpages for the parallel courses in German:
- 401-0251-00L Mathematik I in the Fall semester and
- 401-0252-00L Mathematik II in the Spring semester.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed

406-0252-AAL Mathematics II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Continuation of the topics of Mathematics I, with main focus on multivariable calculus.
Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of these courses.

Content

- Multivariable Differential Calculus:
  functions of several variables, partial differentiation, curves and surfaces in space, scalar and vector fields, gradient, curl and divergence.

- Multivariable Integral Calculus:
  multiple integrals, line and surface integrals, work and flux, Green, Gauss and Stokes theorems, applications.

- Introduction to Partial Differential Equations:
  separation of variables, heat equation, wave equation, Laplace equation.

- Stochastics (Probability and Statistics):
  functions of several variables, partial differentiation, curves and surfaces in space, scalar and vector fields, gradient, curl and divergence.

Lecture notes

See literature

Literature


Prerequisites / notice

Prerequisites:
  familiarity with the basic notions from Calculus, in particular those of function, derivative and integral.

Abstract

Mathematics I covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems, notably through:

- Bretscher, O.: Linear Algebra with Applications, Pearson Prentice Hall.

Subject-specific Competencies

See literature

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The main focus of Mathematics II is multivariable calculus.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of these courses.

Abstract

Competencies

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<th>Conceptual Competencies</th>
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<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Method-specific Competencies</td>
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406-0253-AAL

Mathematics I & II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Mathematics I covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems, notably through linear algebra and calculus, with an emphasis on ordinary differential equations.

The main focus of Mathematics II is multivariable calculus.

Abstract

Mathematics of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of these courses.

Abstract

406-0503-AAL

Stochastics (Probability and Statistics)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2546 of 2667
**Objective**
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

**Content**
- From "Statistics for research" (online)
  - Ch 1: The Role of Statistics
  - Ch 2: Populations, Samples, and Probability Distributions
  - Ch 3: Binomial Distributions
  - Ch 6: Sampling Distribution of Averages
  - Ch 7: Normal Distributions
  - Ch 8: Student's t Distribution
  - Ch 9: Distributions of Two Variables

- From "Introductory Statistics with R (online)"
  - Ch 1: Basics
  - Ch 2: The R Environment
  - Ch 3: Probability and distributions
  - Ch 4: Descriptive statistics and tables
  - Ch 5: One- and two-sample tests
  - Ch 6: Regression and correlation

**Literature**
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  - From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

  - From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed

**Personal Competencies**
- Self-direction and Self-management: assessed

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**529-2001-AAL**  
Chemistry I and II  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
General Chemistry I and II: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium, kinetics, acids and bases, electrochemistry

**Objective**
- Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

**Content**
1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

**Lecture notes**
Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

**Literature**
Housecroft and Constable, CHEMISTRY  
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

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**529-0234-AAL**  
Chemistry I  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
Chemistry I: Chemical bonding and molecular structure, chemical thermodynamics and kinetics, chemical equilibrium.
Acquiring the basics for describing the structure, composition and transformations of the material world. Introduction to thermodynamically determined chemical-physical processes. Use modeling to show how macroscopic phenomena can be understood in terms of atomic and molecular properties. Applications of theory to quantitatively and qualitatively solve simple chemical and environmental problems.

Objective

Content

1. Stoichiometry

2. Atomic structure

3. Chemical bond and its representation
   Spatial structure of molecules. Molecular orbitals. System and environment. Description of the state and changes of state of chemical systems. First law of thermodynamics
   Internal energy, heat and work. Enthalpy and enthalpy of reaction. Standard thermodynamic conditions. Second law of thermodynamics
   Entropy. Entropy changes in the system and in the universe. Reaction entropy due to heat of reaction and due to changes in matter. Gibbs energy and chemical potential.
   Combination of the first and second law of thermodynamics. Reaction Gibbs energy. Mass activities in gases, condensed substances and dissolved species. Gibbs energy in the course of chemical reactions. Equilibrium constant. Chemical equilibrium
   Mass action law, reaction quotient and equilibrium constant. Equilibrium in phase transitions. Acids and bases
   Behavior of substances as acid or base. Dissociation functions of acids. pH concept. Calculation of pH values in acid-base systems and speciation diagrams. Acid-base buffers. Polyprotic acids and bases. Dissolution and precipitation
   Heterogeneous equilibrium. Dissolution process and solubility constant. Speciation diagrams. The carbon dioxide-carbonate equilibrium in the environment.

529-2002-AAL Chemistry II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Erweitern der allgemeinen Grundlagen und Erarbeiten einer Basis, um Prozesse in komplexeren Umweltsystemen (Wasser / Luft / Boden) in ihrem zeitlichen und quantitativen Ablauf verstehen und beurteilen zu können.

Objective

Content

1. Redoxreactions
   Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronoc structure of the elements.

2. Inorganic Chemistry
   Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups. Stereochemistry.
   Recton mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds), chemistry of carbony and carboxyl groups.
   Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronoc structure of the elements.

3. Introduction to organic chemistry
   Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups. Stereochemistry.
   Recton mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds), chemistry of carbony and carboxyl groups.

Lecture notes


Literature


551-0001-AAL General Biology I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2548 of 2667
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

Objective
The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

Content
The first semester focuses on the organizational biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogenetic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
28 Diversity of Life Origin & evolution of eukaryotes
29 Diversity of Life Nonvascular & seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

Lecture notes
No script

Literature

Prerequisites / notice
This is a virtual self-study lecture for non-german speakers of the *Allgemeine Biology I (551-0001-00L) lecture. The exam will be written jointly with the participants of this lecture.

Example exam questions will be discussed during the lectures, and old exam questions are kept by the various student organisations. If necessary, please contact Prof. Uwe Sauer (sauer@ethz.ch) for details regarding the exam.

551-0003-AAL General Biology I+II E- 7 credits 13R U. Sauer, K. Bomblies, O. Y. Martin, A. Widmer
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Biology I: Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

General Biology II: Molecular biology approach to teach the basic principles of biochemistry, cell biology, genetics, evolutionary biology and form and function of vascular plants.

Objective
General Biology I: The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

General Biology II: The understanding basic concepts of biology: the hierarchy of the structural levels of biological organisation, with particular emphasis on the cell and its molecular functions, the fundamentals of metabolism and molecular genetics, as well as form and function of vascular plants.
Content

General Biology I focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogentic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
28 Diversity of Life Origin & evolution of eukaryotes
29 Diversity of Life Nonvascular&seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

General Biology II: The structure and function of biomacromolecules; basics of metabolism; tour of the cell; membrane structure and function; basic energetics of cellular processes; respiration, photosynthesis; cell cycle, from gene to protein; structure and growth of vascular plants, resource acquisition and transport, soil and plant nutrition.

Specifically the following Campbell chapters will be covered:
3 Biochemistry Chemistry of water
4 Biochemistry Carbon: the basis of molecular diversity
5 Biochemistry Biological macromolecules and lipids
7 Cell biology Cell structure and function
8 Cell biology Cell membranes
10 Cell biology Respiration: introduction to metabolism
11 Cell biology Photosynthetic processes
16 Genetics Nucleic acids and inheritance
17 Genetics Expression of genes
18 Genetics Control of gene expression
19 Genetics DNA Technology
35 Plant structure&function Plant Structure and Growth
36 Plant structure&function Transport in vascular plants
37 Plant structure&function Plant nutrition
38 Plant structure&function Reproduction of flowering plants
39 Plant structure&function Plants signal and behavior

| Lecture notes | No script |
| Prerequisites / notice | Basic general and organic chemistry |

This is a virtual self-study lecture for non-German speakers of the *Allgemeine Biology I (551-0001-00L)* and *Allgemeine Biology II (551-0002-00L)* lectures. The exam will be written jointly with the participants of this lecture.

<table>
<thead>
<tr>
<th>701-0023-AAL</th>
<th>Atmosphere</th>
<th>E-</th>
<th>3 credits</th>
<th>6R</th>
<th>E. Fischer</th>
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<tbody>
<tr>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td>Abstract</td>
<td>Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.</td>
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<tr>
<td>Objective</td>
<td>Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.</td>
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<tr>
<td>Content</td>
<td>Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.</td>
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<tr>
<td>Lecture notes</td>
<td>Written information will be supplied.</td>
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<table>
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<tr>
<th>701-0071-AAL</th>
<th>Mathematics III: Systems Analysis</th>
<th>E-</th>
<th>4 credits</th>
<th>9R</th>
<th>R. Knutti, H. Wernli</th>
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<tr>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td>Abstract</td>
<td>The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.</td>
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<tr>
<td>Objective</td>
<td>Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.</td>
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</table>
### 701-0106-AAL  
**Mathematics V: Applied Deepening of Mathematics I - III**  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.  

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.  

**Abstract**  
Selected mathematical topics are presented for later use in more specialised lectures. Part of the topics were already discussed in the lectures Mathematics I-III. Here, they should be shortly recapitulated and most importantly applied to practical problems. If necessary, new mathematical concepts and methods will be introduced in order to solve challenging and inspiring problems from practice.

**Objective**  
The aim of this lecture is to prepare the students for the more specialised lectures. They should become more familiar with the mathematical background, the mathematical concepts and most of all with their application and interpretation.

**Content**  
Practical examples from the following areas will be discussed: ordinary differential equations; eigenvalue problems from linear algebra; systems of linear and nonlinear differential equations; partial differential equations (diffusion, transport, waves).

---

### 701-0243-AAL  
**Biology III: Essentials of Ecology**  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.  

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.  

**Abstract**  
This course assigns reading for students needing further background for understanding ecological processes. Central problems in ecology, including population growth and regulation, the dynamics of species interactions, the influence of spatial structure, the controls over species invasions, and community responses to environmental change will be explored from basic and applied perspectives.

**Objective**  
Students will understand how ecological processes operate in natural communities. They will appreciate how mathematical theory, field experimentation, and observational studies combine to generate a predictive science of ecological processes.

Upon completing the course, students will be able to:

- Understand the factors determining the outcome of species interactions in communities, and how this information informs management.
- Apply theoretical knowledge on species interactions to predict the potential outcomes of novel species introductions.
- Understand the role of spatial structure in mediating population dynamics and persistence, species interactions, and patterns of species diversity.
- Use population and community models to predict the stability of interactions between predators and prey and between different competitors.
- Understand the conceptual basis of predictions concerning how ecological communities will respond to climate change.

**Content**  
Readings from a text book will focus on understanding central processes in community ecology. Topics will include demographic and spatial structure, consumer resource interactions, food webs, competition, invasion, and the maintenance of species diversity. Each of these more conceptual topics will be discussed in concert with their applications to the conservation and management of species and communities in a changing world.

---

### 701-0401-AAL  
**Hydrosphere**  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.  

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.  

**Abstract**  
In this self-study course, students learn about relevant processes that control the water cycle on earth. Energy and mass exchange, mixing and transport processes are described and the coupling of the hydrosphere with the atmosphere and the solid Earth are discussed.

**Objective**  
Qualitative and quantitative understanding on how physical (and geochemical) processes control the natural dynamics in groundwater, lakes ans oceans and constrain the exchange of mass and energy.
Content
Topics of the course.
Physical properties of water (i.e. density and equation of state)
- global water resources
Exchange at boundaries
- energy (thermal & kinetic), gas exchange
Mixing and transport processes in open waters
- vertical stratification, large scale transport
- turbulence and mixing
- mixing and exchange processes in rivers
Groundwater and its dynamics
- ground water as part of the terrestrial water cycle
- ground water hydraulics, Darcy's law
- aquifers and their properties
- hydrochemistry and tracer
- ground water use
Case studies
- 1. Water as resource, 2. Water and climate

Lecture notes
- in addition to the self-learning literature handouts are distributed.

Literature
Textbooks for self-studying.
Surface water,
Chapter 4: Imboden, D.M., and Wüest, A. 'Mixing Mechanisms in Lakes'
Chapter 6.4: Air-Water Partitioning
Chapter 19.2: Bottleneck Boundaries
Ground water:
Chapters 1 - 6, 8, 10, 11.
Optional additional readers.

701-0473-AAL Weather Systems E- 3 credits 6R M. A. Sprenger, I. Thurnherr
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
The students learn about the dynamical features of the Earth's atmosphere. They interpret satellite imagery and learn about basic concepts in dynamical meteorology. The global circulation is briefly discussed, before introducing the Eulerian and the Lagrangian perspective, which are used to study air streams in extratropical cyclones and to investigate basic aspects in mountain meteorology.

Objective
The students are able to
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of the role of moist adiabatic processes for weather systems and why stable water isotopes are useful in this context

Content
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; potential vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer

Lecture notes
Lecture notes and slides

Literature
Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed
Social Competencies: Communication fostered

701-0475-AAL Atmospheric Physics E- 3 credits 6R U. Lohmann

Abstract
This course is a self-study course for MSc students, who like to learn something about Atmospheric Physics but for cannot follow the course Atmosphärenphysik, because that is taught in German. However, the slides and the textbook of the course Atmosphärenphysik, and they form the basis also for this course.

Objective
See entry under LV 701-0475-00L Atmosphärenphysik
Content
See entry under LV 701-0475-00L Atmosphärenphysik
Lecture notes
Powerpoint slides and script from LV 701-0475-00L Atmosphärenphysik will be made available

Literature

Competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed
Social Competencies: Communication assessed
Personal Competencies: Critical Thinking assessed

701-0501-AAL Pedosphere E- 3 credits 6R R. Kretzschmar

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Abstract
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties.

Objective
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

Content
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, physical soil properties and functions, chemical soil properties and functions, soil formation, principles of soil classification, global soil regions, soil fertility, land use and soil degradation.

Literature

Prerequisites / notice
Prerequisites: Basic knowledge in chemistry, biology and geology.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
</tbody>
</table>

701-0721-AAL Psychology E- 3 credits 6R M. Siegrist

Abstract
This self-study course is an introductory course in psychology. This course will emphasize cognitive psychology and the psychological experiment.

Objective
Knowledge of key concepts and exemplary theories of psychology and their relation to “daily” psychology. Comprehension of relation between theory and experiment in psychology.

Goals: Learning how psychologists are thinking, a side change from the ETH natural science perspective to psychological thinking.

Domains of psychology:
- Psychology fields
- Concept definitions of psychology
- Theories of psychology
- Methods of psychology
- Results of psychology

Capability:
Be able to define a psychological research question
Basics understanding of role of psychology

Comprehension:
Psychology as a science of experience and behavior of the human

Content
Einführung in die psychologische Forschung und Modellbildung unter besonderer Berücksichtigung der kognitiven Psychologie und des psychologischen Experiments. Themen sind u.a.: Wahrnehmung; Lernen und Entwicklung; Denken und Problemlösen; Kognitive Sozialpsychologie; Risiko und Entscheidung.

Literature

Prerequisites / notice
Determine with Prof. Dr. Michael Siegrist the chapters in "Zimbardo" which are compulsory reading

Read the two Psychology chapters (6 + 7) from the book of Prof. Roland W. Scholz

752-4001-AAL Microbiology E- 2 credits 4R M. Schuppler

Abstract
Self-study course in microbiology.

Objective
Teaching of basic knowledge in microbiology.

Content
This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology.

Literature
This self-study course is based on the book 'Brock, Biology of Microorganisms'.

Environmental Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

**ECTS**
- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0125-00L</td>
<td>Hydrodynamics and Cavitation</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>O. Supponen</td>
</tr>
</tbody>
</table>

Abstract

This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

Objective

The main learning objectives of this course are:

1. Identify and describe dominant effects in liquid fluid flows through physical modelling.
2. Identify and predict the onset of hydrodynamic instabilities.
3. Describe acoustic wave behaviour in liquids.
4. Explain tension, nucleation and phase-change in liquids.
5. Predict the behaviour of a gas bubble subject to changes in surrounding liquid pressure.
6. Describe hydrodynamic cavitation and its consequences in physical terms.
7. Recognise experimental techniques and industrial and medical applications for cavitation.
8. Read and evaluate research papers on recent research on cavitation and bubble dynamics and communicate the content orally to a multidisciplinary audience.

Content

The course gives an overview on the following topics: basics of hydrodynamics, capillarity, hydrodynamic instabilities, liquid fragmentation. Acoustics in liquids, tension in liquids, phase change. Cavitation and bubble dynamics: single bubbles (nucleation, dynamics, collapse), bubble clouds and cavitating flows. Industrial applications and measurement techniques.

Lecture notes

Class notes and handouts

Literature

Literature will be provided in the course material.

Prerequisites / notice

Fluid dynamics I & II or equivalent

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<td>Creative Thinking</td>
<td>fostered</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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</table>

151-0209-00L Renewable Energy Technologies

Abstract

The first part of the course covers the engineering aspects of the prominent renewable energy technologies: solar (PV and thermal), wind, hydro, geothermal and bioenergy. We further discuss energy storage, renewable transport and renewable heating & cooling. Finally, we introduce the key concepts of the economics of renewable energy and its integration in the energy system.

Objective

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Lecture notes

Lecture Notes containing copies of the presented slides.

Prerequisites / notice

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td></td>
<td>Problem-solving</td>
<td>fostered</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>fostered</td>
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<tr>
<td>Personal Competencies</td>
<td>Cooperation and Teamwork</td>
<td>fostered</td>
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<td></td>
<td>Critical Thinking</td>
<td>fostered</td>
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</table>

151-0213-00L Fluid Dynamics with the Lattice Boltzmann Method

Abstract

The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Objective

Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microwaves among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.
Content

The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow:
   Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   Relativistic fluid dynamics; flows with phase transitions.

Lecture notes

Lecture notes on the theoretical parts of the course will be made available.
Selected original and review papers are provided for some of the lectures on advanced topics.
Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice

The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0293-00L Fundamentals and Applications of Combustion W 4 credits 2V+1U+2A N. Noiray, F. Ernst, C. E. Frouzakis

Note: The previous course title until HS23 "Combustion and Reactive Processes in Energy and Materials Technology"

Abstract

This course will provide an introduction to the fundamentals and the applications of combustion in energy conversion and nanoparticles synthesis. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

Objective

The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

Content


Lecture notes

No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Teaching language, assignments and lecture slides in English

Literature


151-0509-00L Acoustics in Fluid Media: From Robotics to Additive Manufacturing W 4 credits 3G D. Ahmed

Abstract

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices

Lecture notes


Prerequisites / notice

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

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Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving assessed
Project Management fostered
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence assessed
Sensitivity to Diversity fostered
Negotiation fostered
Personal Competencies
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-direction and Self-management assessed

151-0905-00L Medical Technology Innovation - From Concept to Clinics
W 4 credits 3G I. Herrmann

Abstract
Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

Objective
After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

Lecture notes will be available on the moodle.
Literature will be available on the moodle.
Prerequisites / notice
On site presence during (most) of the lectures highly encouraged!
Graded innovation project will require on-site presence.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed
Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

151-0913-00L Introduction to Photonics
W 4 credits 2V+2U R. Quidant, J. Ortega Arroyo

Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
### 151-0927-00L Rate-Controlled Separations in Fine Chemistry

**W** 6 credits 3V+1U  M. Mazzotti, V. Becattini, N. Casas, F. Kiefer

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
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<td></td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
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<td>Self-direction and Self-management</td>
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</table>

**Abstract**

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

**Objective**

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

**Content**

The class covers separation techniques that are central in the purification and downstream processing of chemicals and biopharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

**Lecture notes**

Handouts during the class

**Literature**

Recommendations for text books will be covered in the class

**Prerequisites / notice**

Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)

### 151-0951-00L Process Design and Safety

**W** 4 credits 2V+1U  F. Trachsel, C. Hutter

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
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</table>

**Abstract**

The lecture Process Design and Saftey deals with the fundamentals of project management, scale-up, dimensioning and safety of chemical process equipment and plants.

**Objective**

The objective of the lecture is to expound the engineering design approach of important elements in chemical plant design.

**Content**

Fundamentals in Chemical engineering Design; Project Management, Cost estimate, Materials and Corrosion, Piping and Armatures, Pumps, Reactors and Scale-up, Safety of chemical processes, Patents

**Lecture notes**

The lecture slides will be distributed.

**Literature**


**Prerequisites / notice**

A 1-day excursion including a visit of a chemical plant will be part of the lecture.

### 151-0957-00L Practica in Process Engineering I

**W** 2 credits 2P  D. J. Norris, M. Tibbitt

<table>
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<tr>
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**Abstract**

Practical training at pilot facilities for fundamental processing steps, typical laboratory and pilot facility experiments.

**Objective**

Getting acquainted with unit operations, measuring tools and data processing

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Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2559 of 2667
Content
4 modules in total (3 from Prof. Norris, 1 from Prof. Mark Tibbitt)
Details and dates will be communicated at the beginning of the semester.

Residence Time Distribution
Tibbitt

Perovskite Nanocrystals - Synthesis and Characterization
Norris

ICP Elemental Analysis
Norris

Scanning Electron Microscope Imaging (SEM)
Norris

Lecture notes
Scripts of the specific practice will be available shortly before the modules.

Literature
Own scripts

529-0613-01L Process Simulation and Flowsheeting W 6 credits 3G G. Guillén Gosálbez

Abstract
This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies. Commercial software packages (Aspen) are introduced for solving process flowsheeting and optimization problems.

Objective
This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

Content Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process flowsheeting:
- Flowsheet partitioning and tearing
- Solution methods for process flowsheeting
- Simultaneous methods
- Sequential methods

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
- Non-linear programming, NLP
- Mixed-integer linear programming, MILP
- Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimisation & debugging

Literature
An exemplary literature list is provided below:
- Smith, R. Chemical process design and integration, Wiley (2005).

Prerequisites / notice
A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

▶ Multidisciplinary Courses
The students are free to choose individually Master’s courses from the Course Catalogue of ETH Zurich, ETH Lausanne and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Course Catalogue of ETH Zurich

▶ Semester Project

<table>
<thead>
<tr>
<th>Number</th>
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<td>151-1008-00L</td>
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<td>O</td>
<td>8</td>
<td>17A</td>
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</table>

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2560 of 2667
The subject of the Master Thesis and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

**Abstract**
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master’s program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

**Objective**
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program.

### Industrial Internship

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<td>Access to the company list and request for recognition under <a href="http://www.mavt.ethz.ch/praxis">www.mavt.ethz.ch/praxis</a>. No registration required via myStudies.</td>
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**Abstract**
The main objective of the minimum twelve-week internship is to expose Master’s students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

**Objective**
The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

### Science in Perspective

- see Science in Perspective: Language Courses ETH/UZH
- see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

### Master’s Thesis

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<tr>
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<th>Hours</th>
<th>Lecturers</th>
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</table>

**Abstract**
Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

**Objective**
The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

### Process Engineering Master - Key for Type

<table>
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<tr>
<th>Key</th>
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<td>Recommended, not eligible for credits</td>
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<tr>
<td>W</td>
<td>Eligible for credits and recommended</td>
<td>Z Courses outside the curriculum</td>
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<tr>
<td>W+</td>
<td>Eligible for credits</td>
<td>Dr Suitable for doctorate</td>
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### Key for Hours

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<td>G</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**
European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
Global History of Urban Design I

The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.

### Content

- **01. The History and Theory of the City as Project**
- **02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus**
- **03: The Idea of the Polis: Rome, Greece and Beyond**
- **04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi**
- **05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles**
- **06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization**
- **07: The City of Labor: Company Towns as Cross-Cultural Phenomenon**
- **08: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again**
- **09: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham**
- **10: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid**

### Literature


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

### Prerequisites / notice

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

### Competencies

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<tr>
<th>Number</th>
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<td>2V</td>
<td>H. Fischer-Tiné</td>
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<td>052-0801-00L</td>
<td>Global History of Urban Design I</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
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### Abstract

A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture series looks at the key aspects of these modernization processes and asks about their continuing relevance for our times. The regional focus lies on the British, where these processes took place for the first time.

### Objective

At the end of this lecture course, students can: (a) highlight the most important changes in the "long nineteenth century" in Britain (b) explain their long-term effects (also for other European countries); and (c) relate these changes to global developments today.

### Content

The thematic foci include: Industrialization, urban growth, democratisation and mass politics, shifting gender roles and ideals, and the emergence of consumerism and leisure culture.

### Lecture notes

Power Point Slides and references will be made available in digital form during the course of the semester.

### Literature

Mandatory and further reading will be listed on the course plan that is made available as from the first session.
851-0685-00L  Data and Society  

Abstract
This lecture series explores the multifaceted role of data in shaping contemporary society, governance, and individual lives. The course equips students with a critical understanding of how data is made, managed, and preserved, and its implications for societal norms and individual rights.

Objective
At the end of the term, students will be able to:
- reflect concepts that capture the performativity of data
- assess the implications of data practices for social and political ordering
- identify key actors, sites, and domain contexts of data practices

Competencies
Subject-specific Competencies
- Concepts and Theories
Method-specific Competencies
- Analytical Competencies
- Problem-solving
Social Competencies
- Communication
- Sensitivity to Diversity
Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Self-awareness and Self-reflection

851-0067-00L  Science Studies between economic growth, social needs and critique  

Abstract
Science has become a subject of research in its own right since the 20th century: the field of "science studies" examines the organization of science, its social benefits, its contribution to economic growth or its impact on people and nature. The seminar introduces the history of this research and sheds light on its applied and critical dimensions.

Objective
Using historical sources from the field of science studies, students learn to understand societal expectations and criticisms of the sciences in the 20th and 21st centuries.

Content
The value of science for social and economic development has been an issue of debate since the 20th century. At the same time, science became a subject of research in its own right: the sociology of science in the 1930s dealt with the social benefits ("Science for Social Needs") and the organization of science. Since the 1950s, the research field of the "Science of Science" has quantified scientific publications ("Science Citation Index") and attempted to measure the relationship between research and innovation, between education and economic growth (OECD studies). Science seemed to promise scientific and technological progress, innovation and economic growth-both in the industrialized countries and, with the help of "technology transfer", to the then so-called "developing countries". At the same time, in the field of "technology assessment", the sciences were criticized for causing risks and damages to humans and nature (e.g. through pesticides or biotechnology) or entailing effects of social inequality.

The fact that the sciences have been the subject of debate since the 20th century is not only a matter of general public interest. It is also the effect of the development and funding of research fields that deal with measures to increase innovation or with the benefits and risks of science. The seminar deals with the history of this research in its political and economic contexts as well as in its applied and critical function. It examines the knowledge on which historical and current expectations of science in politics and society are based.

Literature
- Donna Haraway: Class, Race, Sex, Scientific Objects of Knowledge (1982)
- Ziauddin Sardar, Dawud G. Rosser-Owen: Science Policy and Developing Countries (1977)
- J.D. Bernal: The Social Function of Science (1939)
- Hilary Rose & Steven Rose: Science and Society (1969)
- Christopher Freeman: Economics of Research and Development (1977)
- Ariane Leendertz: "Finalisierung der Wissenschaft". Wissenschaftstheorie in den politischen Deutungskämpfen der Bonner Republik (2013)
- Elena Aronova & Simone Turchetti: Science Studies During the Cold War and Beyond (2017)
- Elena Aronova: Scientometrics with and without Computers: The Cold War Transnational Journeys of the Science Citation Index (2016)
- Gerardo Ienna: The Double Legacy of Bernalism in Science Diplomacy (2022)
- Gerardo Ienna: The Double Legacy of Bernalism in Science Diplomacy (2022)
- Elena Aronova: Scientometrics with and without Computers: The Cold War Transnational Journeys of the Science Citation Index (2016)
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Competencies
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Social Competencies
- Sensitivity to Diversity
Personal Competencies
- Adaptability and Flexibility
- Critical Thinking

851-0077-00L  Philosophy of War  

Abstract
In the course we read classical texts from the field of philosophy of war (Clausewitz, Sun Tzu, Tolstoy, Machiavelli, Kant) and focus on questions such as: what is war? Strategy and tactics in war? Ethics of war? War and Politics?

Objective
Students learn about the different types of argumentative texts and their historical, social, political and ethical context. They learn to understand the descriptive and critical value of texts in regard to the topic of war.

851-0019-00L  Insect Histories: Bugs that Made the Modern World  

Abstract
The seminar explores insects as historical actors and their diverse interactions with human societies over time and space. It offers an overview of recent approaches in environmental history and multispecies ethnography while providing an analytical framework to understand global processes of natural resource exploitation, knowledge formation, and imperialism.

Objective
The objective is to analyze human-insect interactions by identifying key historical factors (economic, scientific, political). Students will integrate current frameworks in the study of environmental history through the combination of primary sources and interdisciplinary research. They will develop skills rooted in their interest in insects and learn to translate them into feedback to peers.
851-0201-00L Literature and History

**Abstract**

Literature and history have often coexisted, "dialogued". History is a recurring theme in many literary works. In this seminar, we will explore the relationship between literature and history.

**Objective**

The aim is to evoke History as a source of creation for writers. The aim is to identify the bridges built by this transdisciplinarity, and to question the way in which History is "rewritten" by literature, after having been at its origin.

**Content**

Literature and history have often coexisted, "dialogued". History is a recurring theme in many literary works. In this seminar, we will explore the relationship between literature and history. We'll look at several periods of world history, from America to Europe and Africa. The aim is to evoke History as a source of creation for writers. The aim is to identify the bridges built by this transdisciplinarity, and to question the way in which History is "rewritten" by literature, after having been at its origin. To illustrate our points, we will draw on 20th- and 21st-century novels by French, Haitian and Algerian authors...

- Rosalie L'intâme, Evelyne Trouillot
- Le Manuscrit de Port-Ébène, Dominique Bona
- L'Affaire de l'esclave Furcy, Mohammed Alaissou
- Cris, Laurent Gaudé (First World War)
- Sigmaringen, Pierre Assouline (World War II)
- Avant que les ombres s'effacent, Louis-Philippe Dalember (Second World War)
- Où j'ai laissé mon âme, Jérôme Ferrari (Second World War & Algerian War)

851-0101-56L From Cotton to Cocaine: Commodities That Made History (c.1700-1950)

**Abstract**

Each session focuses on a particular commodity and explores how its production, trade and consumption was entangled with important political, social and cultural developments. Taken together, the case studies (ranging from agricultural crops, via chemically produced drugs to mechanical marvels such as the gramophone) provide a picture of major global transformations in the past 300 years.

**Objective**

On one level, the course aims to familiarise students with a currently much debated approach to the writing of global history, namely the history of commodities. Each case study is used to deepen the participants' understanding of complex historical developments by telling seemingly simple stories in a global frame. Thus, for instance, the session on sugar explores plantation economies in the Caribbean and the transatlantic slave trade as well as shifting patterns of diet and consumption in Europe. The session on rubber focuses on botanical expeditions in Latin America, the deployment of Chinese coolies on Malaysian Rubber farms and the rise of the automobile mass production in the USA. By linking the familiar to the unfamiliar and 'exotic' the inter-cultural sensitivity of the students will be enhanced.

On a second level, the analysis and understanding of these complex interconnections, it is hoped, will help students to get a more nuanced understanding of the historical process that is currently referred to as 'globalization' and overcome the eurocentric perspective that still structures many scholarly and media writings on this topic.

851-0125-65L A Sampler of Histories and Philosophies of Mathematics

**Abstract**

This course will review several case studies from the ancient, medieval and modern history of mathematics. The case studies will be analyzed from various philosophical perspectives, while situating them in their historical and cultural contexts.

**Objective**

The course aims are:
1. To introduce students to the historicity of mathematics
2. To make sense of mathematical practices that appear unreasonable from a contemporary point of view
3. To develop critical reflection concerning the nature of mathematical objects
4. To introduce various theoretical approaches to the philosophy and history of mathematics
5. To open the students' horizons to the plurality of mathematical cultures and practices

**Competencies**

- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Sensitivity to Diversity fostered
- Personal Competencies: Critical Thinking fostered

851-0453-00L Artificial Intelligence and Human Values

**Abstract**

This course introduces students to the ethical, political and legal debates and transformations in relation to Artificial Intelligence and provides students with concepts and methods from the constructivist and interpretive social sciences to work towards responsible and democratic human-technology futures.

**Objective**

The main objectives of the course are to enable students to 1) identify the ways in which human values and developments of AI technologies are entangled, 2) articulate what is significant about contemporary transformations in AI and society, and 3) participate and shape the relationship between human values and AI as citizens and professionals.

**Content**

The growing presence of AI tools for public use, for public administration, inside corporations and in scientific research raises many questions about the ethical, political, legal consequences of these technologies. This course is built around multiple sites of encounter among human values and AI, including bodies, persons, cities, labs, law, and environment. In each site, we inquire about what and whose values are being prioritized and with what consequences. The course also investigates existing best-practices around "align" human values with AI (e.g., human-centric design, alignment, reproducibility, transparency, explainability) and introduces students to regimes of ethics and governance of AI being proposed in jurisdictions around the world. Students learn to unpack the values and assumptions in existing techniques and frameworks for the design and governance of AI and to engage constructively with diverse stakeholders to shape the human-technology future towards aims that are reflexive, responsible, and democratic.

851-0157-28L Life and Death

**Abstract**

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.
<table>
<thead>
<tr>
<th>Objective</th>
<th>There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and mortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0540-00L</td>
<td>Of Stainless Steel and Biocompatible Ink. History of Materials Science.</td>
</tr>
<tr>
<td>Abstract</td>
<td>The seminar examines the history of materials science. Why and how were materials characterized, developed and tested? How did things as diverse as wood, concrete, ceramics and polymers become objects of a single discipline? How did social imaginaries and technical conditions affect scientific work with and on materials?</td>
</tr>
<tr>
<td>Objective</td>
<td>Students learn to critically read and interpret different types of texts. They will be familiarised with the interdependencies of technical, scientific and social change. They reflect on (material) scientific practices.</td>
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<tr>
<td>Content</td>
<td>The seminar discusses the socio-technical conditions and effects of materials research from a historical perspective in the 20th century. We observe physicists, chemists and engineers, as well as concrete, foams and electron microscopes, in research laboratories and materials testing institutes, in articles and patents.</td>
</tr>
<tr>
<td>Competencies</td>
<td>Subject-specific Competencies: Concepts and Theories; Analytical Competencies; Communication; Cooperation and Teamwork; Creative Thinking; Critical Thinking.</td>
</tr>
<tr>
<td>851-0541-00L</td>
<td>Truth and Historical Injustice: The Production of Knowledge about Past Mass Atrocities</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course deals with the scientific production of knowledge about past mass atrocities. It looks at the interplay of different disciplines, methods and technological means that have been involved in this production over time. Further, it poses the question of what truth can mean in this context.</td>
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<tr>
<td>Objective</td>
<td>The students a) know the main features of the discussion about the truth in the reconstruction of past events; b) have an understanding of the interplay, but also the coexistence of different scientific methods and technological means in the multidisciplinary production of knowledge about mass crimes; c) have knowledge of important processes of dealing with past mass crimes from the second half of the 20th century onwards.</td>
</tr>
<tr>
<td>Content</td>
<td>When discussing the truthfulness of the academic study of the past, politically and ideologically motivated mass crimes are often cited as historical events in order to substantiate the necessity of a claim to truth. In doing so, moral arguments can be made or historical truth can be asserted as a basic prerequisite for living together in a democratic society under constitutional conditions. The production of knowledge about past atrocities has always been an endeavour in which various scientific disciplines have been involved. The multidisciplinary character of the production of knowledge about mass crimes has become even more accentuated since the second half of the 20th century, not least due to the emergence of new technological possibilities. The course offers a brief introduction to the discussion about the meaning of truth about past events. It looks at how different scientific approaches - from the humanities to the natural sciences - have been involved in coming to terms with mass crimes and how they have been related to each other. It deals with the question of what role certain techniques and technologies have played in the production of knowledge about past atrocities and how this has changed over time. These techniques and technologies range from the evaluation of documents and the taking of testimonies to specialised database programs, genetic analysis or imaging techniques, to digital technologies for the procurement of information on social media and the internet or for the modelling of past events. In addressing these questions, the course looks at processes of dealing with the past from the middle of the 20th century to the 21st century in Europe, Latin America and Africa.</td>
</tr>
<tr>
<td>Competencies</td>
<td>Subject-specific Competencies: Concepts and Theories; Techniques and Technologies; Analytical Competencies; Critical Thinking.</td>
</tr>
<tr>
<td>851-0202-00L</td>
<td>Digital Humanities: Methods, Challenges, Perspectives</td>
</tr>
<tr>
<td>Abstract</td>
<td>In the 21st century, the humanities and the social sciences are undergoing a ground-breaking transformation: Data-driven, collaborative projects open up new opportunities. Which are the promises and the challenges of digital methods? The lecture series provides an overview of the latest developments.</td>
</tr>
<tr>
<td>Objective</td>
<td>— exploring the most important theoretical and methodological approaches since 2000 — understanding terms and procedures — using digital texts, images and metadata — reflecting on the conditions, opportunities and problems of digital methods</td>
</tr>
<tr>
<td>Content</td>
<td>The possibilities (Franco Moretti, Graphs, Maps, Trees, Verso 2005; Andrew Piper, Enumerations, Chicago UP 2018) and pitfalls (Franco Moretti, The Wrong Move, Konstanz UP 2022) of cultural history under digital conditions require critical reflection and evaluation. The lecture will explore showcases and pioneering work, annotated texts, images, metadata and interfaces provided by libraries, archives and museums. Research approaches and practical applications will be presented and evaluated.</td>
</tr>
<tr>
<td>Competencies</td>
<td>Personal Competencies: Critical Thinking.</td>
</tr>
<tr>
<td>851-0297-00L</td>
<td>Manipulation in Literature and Cultural History</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture focuses on the manipulation and control of individuals and the masses. The power of manipulation is based on subtle use of persuasive linguistic elements and knowledge of the desires and fears of the intended audience. In addition to a theoretical overview, the lecture concentrates on the literary and discursive texts that dispute the control of protagonists.</td>
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<tr>
<td>Objective</td>
<td>Students will learn about manipulation as a linguistic and narrative phenomenon steeped in myth and classical rhetoric. Against the backdrop of cultural-historical developments, particularly with regard to major changes in media technology, we will examine how the reach of manipulation was extended from the individual to the masses. Students will be able to refine their critical discourse analysis skills and interdisciplinary abilities by studying texts from literature, politics, sociology, philosophy and psychoanalysis which reflect this shift in emphasis.</td>
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Content

Since the dawn of time mankind has exerted influence over others through the utilisation of certain techniques: initially for self-preservation – for example the interpretation of Sigmund Freud in Totem und Tabu. Later, desire became the driving force – centre stage: the desire for pleasure, power and control. Manipulation manifests itself in the form of characters and words, it is an authentically linguistic occurrence: classical antiquity, with the rhetoric, develops a system of verbal power of persuasion and, already then, questions were being raised in literary and discursive texts about how people could, or even should, manipulate. The exertion of influence and its impact will be clearly described, propagated, commented upon, criticised and ironised.

In contrast to oppressive overpowering, the power of manipulation (in Latin, manus hand, plere fill) is on the one hand, based on the subtle use of persuasive linguistic elements – it is always a (literary) discourse, too – and on the other, on knowing precisely what the fantasies, desires and fears of the manipulated are. The discourse of manipulation has its beginnings in the age of sophists and their belief in an omnipotence of language and rhetoric. It underwent further transformation under political and psychological signs in the early modern period through Giordano Bruno and Niccolò Machiavelli and culminated in the 20th century in a critique of the deception strategies of the ‘culture industry’ (T.W Adorno) and ‘psychotechnology’ (B. Stiegler) in global capitalism. Nowadays social media is the ‘radicalisation machine’ (J. Ebner) that present new challenges for society. Written in the 19th century, the Protocols of the Elders of Zion already gave indications of how present-day conspiracy theorists would manipulate their audience, and its impact can still be felt today. Since manipulation is a linguistic, narrative and also literary phenomenon, the central theme of the lecture is how in literature itself this often politically controversial and manipulative behaviour is picked up and reflected through poetry: such as in Tristan from Gottfried von Strassburg, Goethe’s Wilhelm Meister, Friedrich Schiller’s Die Verschwörung des Fiesco zu Genua or Heinrich von Kleist’s Der zerbrochene Krug, the works of Edgar Allan Poe and Thomas Mann (Mario und der Zauberer) and, most recently in Eckhart Nickel’s novel, Hysteria.

Competencies

Subject-specific Competencies
- Techniques and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Method-specific Competencies
- Communications
- Cooperation and Teamwork
- Sensitivity to Diversity
- Negotiation

Social Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

851-0527-00L
Introduction to the History of Technology: Concepts, and Current Debates

Abstract

Technology and society cannot be separated: No society functions without technology. The seminar offers a problem-oriented introduction to basic questions of the history of technology, introduces approaches to the history of technology and discusses selected, ongoing debates.

Objective

The course seeks to provide a critical introduction to the issues, methods, and selected areas of research in the history of technology.

Content

History of technology investigates technological developments that arise in specific historical contexts. These developments are perceived by social groups or entire societies as a means of social change and ultimately find use or are forgotten. The questions that history of technology poses derive from the technological and social change that are a product of contemporary orientation and thinking; current historiographical methods provide the tools for answering these questions.

851-0226-00L
Postcolonial Readings

Abstract

The history of colonialism in the modern age begins with Christopher Columbus who, as Todorov has well told us, did not “discover” anything, but crossed the Ocean in search of riches, bringing with him a baggage of violence, stereotypes and violent conquest of resources and bodies. And from here, from that 1492, the story became one of blood and struggle.

Objective

The course will be based on case studies, linked to national realities (Brazil, Senegal, Eritrea, Great Britain, Italy, Peru, Somalia, etc.) and to physical places (the front, the museum, the field, the street, the body), to see how in different contexts, despite the peculiarity of the context, the dilemmas that are attempted to be answered are in fact very similar.

Content

WE are here, because YOU have been there, have you ever heard that phrase? In a university lecture hall? In an anti-racist demonstration? In a play? In a discussion on the bus? The YOU represents Europe and in a broader sense the West, the WE the peoples who suffered colonization by the very West that portrayed itself as a beacon of civilization. The history of colonialism in the modern age begins with Christopher Columbus who, as Todorov has well told us, did not “discover” anything, but crossed the Ocean in search of riches, bringing with him a baggage of violence, stereotypes and violent conquest of resources and bodies. And from here, from that 1492, the story became one of blood and struggle. It is a story that has covered a time span from precisely 1492 to the present, ranging from human trafficking to the extractive, and accumulation, policies of our contemporary times. The consequences of all this violence are sadly still visible on the body of the world, open wounds that bleed. Wounds in which lurk prejudice, systemic racism and murder.

To examine these consequences, to understand how contemporary societies in the global north and south, are still torn apart by this history that never seems to pass; we will rely on literature, on “postcolonial” texts that will show us the complexity of what exists. The course will be based on case studies, linked to national realities (Brazil, Senegal, Eritrea, Great Britain, Italy, Peru, Somalia, etc.) and to physical places (the front, the museum, the field, the street, the body), to see how in different contexts, despite the peculiarity of the context, the dilemmas that are attempted to be answered are in fact very similar.

The lecture will examine the body of the colonized/migrant as a field of battle and resistance in real and metaphorical wars. Place where the stereotype is overthrown through a will for personal agency. Colonial space and the consequent postcolonial space is a hierarchical space where instruments of violence and oppression do not provide for the agency of the colonized subject or in the contemporary case of the migrant subject placed by power structures in a space of subalternity. But subjects are born free and though in a confined space seek their own path to freedom and awareness. In ways that are perhaps paradoxical in our eyes, but certainly effective in a very limited space granted. In the three lectures, through literary texts, three case studies related to as many contexts will be examined to understand precisely this tension between enclosed space and the search for freedom. A tension between (unjust) rules imposed, malevolent looks imposed and granted. In the three lectures, through literary texts, three case studies related to as many books will be examined to understand precisely this tension between enclosed space and the search for freedom. A tension between (unjust) rules imposed, malevolent looks imposed and granted. In the three lectures, through literary texts, three case studies related to as many books will be examined to understand precisely this tension between enclosed space and the search for freedom. A tension between (unjust) rules imposed, malevolent looks imposed and granted.

851-0549-00L
WebClass Introductory Course History of Technology

Abstract

Technology stands for innovation and catastrophes: it works as a dream machine and is associated with the most diverse ways of utilization. In WebClass Introductory Course History of Technology students become familiar with explanations for how technology works within complex economic, political and cultural contexts, by interpreting and researching texts and authoring a student manual.
Students are introduced into how technological innovations take place within complex economic, political and cultural contexts. They get to know basic theories and practices of the field by acquiring the skills to interpret texts, to compare arguments, to research additional sources and complementary material and to author a common essay. All of this will yield into a student manual on the four core topics: technology and innovation, technology and catastrophes, technology as a dream machine and technology and association. The course language is German, and even if many texts will be in English, the ability to read and understand German is mandatory.


### Literature

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0360-00L</td>
<td>The Tower of Babel: From Babylon to Babel  Fish</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Gerard</td>
</tr>
</tbody>
</table>
| Abstract     | "Will the vocabularies never cease clashing/Werden die Wörterbücher immer streiten/Will the bickerwords never grow silent."
- Eugene Jolas, "Babel: 1940"
| Objective    | To situate contemporary discussions of machine translation in relation to earlier literary and philosophical reflections on the problem of linguistic diversity. To gain familiarity with historical origins of machine translation and the stages of its development until the present. To draw historical, thematic, and conceptual connections between the emergence of machine translation in the middle of the twentieth century and the impulses driving post-war literary and theoretical texts. To apply information theory to the analysis of literary texts. To use literary texts to interrogate the operation of telecommunications systems and the assumptions on which those systems rest. |
| 851-0281-00L | The Knowledge of Poetry | W    | 3    | 2V    | C. Jany |
| Abstract     | Novalis once described poetry as “the mind's inherent way of acting”. Thinking takes place in verses and images, rather than concepts and formulas. If this were true, every spontaneous cognition would amount to poetry and each thought essentially to a poem – a structure combining and concentrating ideas, perceptions, and emotions. Knowledge and poetry would be one. |
| Objective    | Such is the promise literature has made since its inception, a promise we will examine in this class by considering mainly lyrical compositions in verse, from the beginnings to the present. The central question is: What do poems know and what is the relationship between thinking in verse and technical and scientific knowledge? |
| 851-0077-00L | Philosophy of War | W    | 3    | 2S    | O. Del Fabbro |
| Abstract     | In the course we read classical texts from the field of philosophy of war (Clausewitz, Sun Tzu, Tolstoy, Machiavelli, Kant) and focus on questions such as: what is war? Strategy and tactics in war? Ethics of war? War and Politics? |
| Objective    | Students learn about the different types of argumentative texts and their historical, social, political and ethical context. They learn to understand the descriptive and critical value of texts in regard to the topic of war. |
| 851-0201-00L | Literature and History | W    | 3    | 2V    | L.-P. Dalembert |
| Abstract     | Literature and history have often coexisted, “dialogued”. History is a recurring theme in many literary works. In this seminar, we will explore the relationship between literature and history. |
| Objective    | The aim is to evoke History as a source of creation for writers. The aim is to identify the bridges built by this transdisciplinarity, and to question the way in which History is "rewritten" by literature, after having been at its origin. |
Literature and history have often coexisted, "dialogued". History is a recurring theme in many literary works. In this seminar, we will explore the relationship between literature and history. We’ll look at several periods of world history, from America to Europe and Africa. The aim is to evoke History as a source of creation for writers. The aim is to identify the bridges built by this transdisciplinarity, and to question the way in which History is "rewritten" by literature, after having been at its origin. To illustrate our points, we will draw on 20th- and 21st-century novels by French, Haitian and Algerian authors...

- Rosalie L'infâme, Evelyne Trouillot
- Le Mansucri de Port-Ébène, Dominique Bona
- L'Affaire de l'esclave Furdy, Mohammed Alissoua
- Cris, Laurent Gaudé (First World War)
- Sigmarigen, Pierre Assouline (World War II)
- Avant que les ombres s'effacent, Louis-Philippe Dalembert (Second World War)
- Où j’ai laissé mon âme, Jérôme Ferrari (Second World War & Algerian War)

851-0304-00L  Science Fiction  W  3 credits  2S  A. Kilcher, S. Lohmann

Abstract

Literature in general can be seen as fundamentally concerned with the forms and functions of knowledge and (sometimes scientific) understanding, but the genre of science fiction is unique in that it literalises this approach in a far-reaching fashion as the future of science and technology. We will explore the form and the "science of literature" through a diverse range of science fiction texts.

Objective

- Concept and history of science fiction
- Theory of science fiction and related forms (e.g. utopia, fantasy)
- Contexts of the history of knowledge and technology in the 19th and 20th centuries.

Content

This course introduces students to the various forms and functions of knowledge and science in literature, particularly within the realm of science fiction, the genre that most directly epitomises this fundamental connection within literary texts.

In analysing how it shapes our understanding of ourselves and of supposedly inalterable facts about the reality we inhabit, we will examine how science fiction demonstrates that fiction is neither fundamentally in conflict with scientific knowledge, as previously supposed, nor a mere vehicle for its celebration, as still commonly presumed of science fiction. Instead, the genre, with its radical investigations into other forms of being, fearing and hoping, plays a crucial role in the social formation, order and negotiation of knowledge. As such, science fiction also represents a vital thought experiment regarding the "science of fiction", i.e. the development of a knowledge of literature and the many fascinating ways in which it helps us to know our own world better, in turn.

In this course, we will take a systematic and theory-based approach to a deeper understanding of science fiction, particularly concerning its historical background, unique aesthetic/narrative tools, and relationship with the critical and technocultural contexts that shape it.

Employing contemporary theoretical approaches, we will discuss a variety of themes within primary texts alongside diverse critical sources, all of which ultimately relate to knowledge and knowability. Particular areas of focus may include: other worlds and alien existences; altered temporality and alternate histories; utopia and dystopia; climate fiction and the Anthropocene; trans-, posthumanist and cyborg identities; robots and AI; and alternative futurisms. Moreover, the course will thereby also engage with the fundamental (and at times overlooked) role of order and presentation of knowledge, i.e. its aesthetic and narrative forms, within science and literature.

851-0297-00L  Manipulation in Literature and Cultural History  W  3 credits  2V  S. S. Leuenberger

Abstract

This lecture focuses on the manipulation and control of individuals and the masses. The power of manipulation is based on subtle use of persuasive linguistic elements and knowledge of the desires and fears of the intended audience. In addition to a theoretical overview, the lecture concentrates on the literary and discursive texts that dispute the control of protagonists.

Objective

Students will learn about manipulation as a linguistic and narrative phenomenon steeped in myth and classical rhetoric. Against the backdrop of cultural-historical developments, particularly with regard to major changes in media technology, we will examine how the reach of manipulation was extended from the individual to the masses. Students will be able to refine their critical discourse analysis skills and interdisciplinarity abilities by studying texts from literature, politics, sociology, philosophy and psychoanalysis which reflect this shift in emphasis.

Content

Since the dawn of time mankind has tried to exert influence over others through the utilisation of certain techniques: initially for self-preservation – for example the interpretation of Sigmund Freud in Totem and Tabu. Later, desire became the driving force – centre stage: the desire for pleasure, power and control. Manipulation manifests itself in the form of characters and words. It is an authentically linguistic occurrence: classical antiquity, with the rhetoric, develops a system of persuasive elements and knowledge of the desires and fears of the intended audience. In contrast to oppressive overpowering, the power of manipulation (in Latin, manus hand, plere fill) is always a literary discourse, too – and on the other, on knowing precisely what the fantasies, desires and fears of the manipulated are. The discourse of manipulation has its beginnings in the age of sophists and their belief in an omnipotence of language and rhetoric. It underwent further transformation under political and psychological signs in the early modern period through Giordano Bruno and Niccolò Machiavelli and culminated in the 20th century in a critique of the deception strategies of the 'culture industry' (T.W Adorno) and "psychotechnology" (B. Stiegler) in global capitalism. Nowadays social media is the "radicalisation machine" (J. Ehler) that present new challenges for society. Written in the 19th century, the Protocols of the Elders of Zion already gave indications of how present-day conspiracy theorists would manipulate their audience, and its impact can still be felt today. Since manipulation is a linguistic, narrative and also literary phenomenon, the central theme of the lecture is how in literature itself this often politically controversial and manipulative behaviour is picked up and reflected through poetry: such as in Tristan from Gottfried von Strassburg, Goethe’s Wilhelm Meister, Friedrich Schiller’s Die Verschwörung des Fiesco zu Genua or Heinrich von Kleist’s Der zerbrochene Krug, the works of Edgar Allan Poe and Thomas Mann (Mario und der Zauberer) and, most recently in Eckhart Nickel’s novel, Hysteria.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies

Method-specific Competencies
- Media and Digital Technologies
- Problem-solving
- Cooperation and Teamwork
- Sensitivity to Diversity
- Negotiation

Social Competencies
- Communication
- Creativity Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Personal Competencies
- Adaptive and Flexible

851-0226-00L  Postcolonial Readings  W  3 credits  2V  I. Scego

Abstract

Since the dawn of time mankind has tried to exert influence over others through the utilisation of certain techniques: initially for self-preservation – for example the interpretation of Sigmund Freud in Totem and Tabu. Later, desire became the driving force – centre stage: the desire for pleasure, power and control. Manipulation manifests itself in the form of characters and words. It is an authentically linguistic occurrence: classical antiquity, with the rhetoric, develops a system of persuasive elements and knowledge of the desires and fears of the intended audience. In contrast to oppressive overpowering, the power of manipulation (in Latin, manus hand, plere fill) is always a literary discourse, too – and on the other, on knowing precisely what the fantasies, desires and fears of the manipulated are. The discourse of manipulation has its beginnings in the age of sophists and their belief in an omnipotence of language and rhetoric. It underwent further transformation under political and psychological signs in the early modern period through Giordano Bruno and Niccolò Machiavelli and culminated in the 20th century in a critique of the deception strategies of the 'culture industry' (T.W Adorno) and "psychotechnology" (B. Stiegler) in global capitalism. Nowadays social media is the "radicalisation machine" (J. Ehler) that present new challenges for society. Written in the 19th century, the Protocols of the Elders of Zion already gave indications of how present-day conspiracy theorists would manipulate their audience, and its impact can still be felt today. Since manipulation is a linguistic, narrative and also literary phenomenon, the central theme of the lecture is how in literature itself this often politically controversial and manipulative behaviour is picked up and reflected through poetry: such as in Tristan from Gottfried von Strassburg, Goethe’s Wilhelm Meister, Friedrich Schiller’s Die Verschwörung des Fiesco zu Genua or Heinrich von Kleist’s Der zerbrochene Krug, the works of Edgar Allan Poe and Thomas Mann (Mario und der Zauberer) and, most recently in Eckhart Nickel’s novel, Hysteria.

Competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies

Method-specific Competencies
- Media and Digital Technologies
- Problem-solving
- Cooperation and Teamwork
- Sensitivity to Diversity
- Negotiation

Social Competencies
- Communication
- Creativity Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Personal Competencies
- Adaptive and Flexible
The history of colonialism in the modern age begins with Christopher Columbus who, as Todorov has well told us, did not "discover" anything, but crossed the Ocean in search of riches, bringing with him a baggage of violence, stereotypes and violent conquest of resources and bodies. And from here, from that 1492, the story became one of blood and struggle.

The lecture will examine the body of the colonized/migrant as a field of battle and resistance in real and metaphorical wars. Place where the stereotype is overthrown through a will for personal agency. Colonial space and the consequent postcolonial space is a hierarchical space where instruments of violence and oppression do not provide for the agency of the colonized subject or in the contemporary case of the migrant subject placed by power structures in a space of subalternity. But subjects are born free and though in a confined space seek their own path to freedom and awareness. In ways that are perhaps paradoxical in our eyes, but certainly effective in a very limited space granted. In the three lectures, through literary texts, three case studies related to as many books will be examined to understand precisely this tension between enclosed space and the search for freedom. A tension between (unjust) rules imposed, malevolent looks imposed and one's own body, one's own moral integrity.

Economics

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<tr>
<th>Number</th>
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<td>851-0626-01L</td>
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<td>2V</td>
<td>I. Günther</td>
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<td>851-0609-06L</td>
<td>Governing the Energy Transition</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>T. Schmidt, L. P. Fesenfeld</td>
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<tr>
<td>363-0387-00L</td>
<td>Corporate Sustainability</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Hoffmann, C. Bening-Bach, B. Girod, L. Miheé</td>
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</table>

Objective

The course will be based on case studies, linked to national realities (Brazil, Senegal, Eritrea, Great Britain, Italy, Peru, Somalia, etc.) and to physical places (the front, the museum, the field, the street, the body), to see how in different contexts, despite the peculiarities of the context, the dilemmas that are attempted to be answered are in fact very similar.

Content

WE are here, because YOU have been there, have you ever heard that phrase? In a university lecture hall? In an anti-racist demonstration? In a play? In a discussion on the bus? The YOU represents Europe and in a broader sense the West, the WE the peoples who suffered colonization by the very West that portrayed itself as a beacon of civilization. The history of colonialism in the modern age begins with Christopher Columbus who, as Todorov has well told us, did not "discover" anything, but crossed the Ocean in search of riches, bringing with him a baggage of violence, stereotypes and violent conquest of resources and bodies. And from here, from that 1492, the story became one of blood and struggle. It is a story that has covered a time span from precisely 1492 to the present, ranging from human trafficking to the extractive, and accumulation, policies of our contemporary times. The consequences of all this violence are sadly still visible on the body of the world, open wounds that bleed. Wounds in which lurk prejudice, systemic racism and murder.

To examine these consequences, to understand how contemporary societies in the global north and south, are still torn apart by this history that never seems to pass; we will rely on literature, on "postcolonial" texts that will show us the complexity of what exists. The course will be based on case studies, linked to national realities (Brazil, Senegal, Eritrea, Great Britain, Italy, Peru, Somalia, etc.) and to physical places (the front, the museum, the field, the street, the body), to see how in different contexts, despite the peculiarities of the context, the dilemmas that are attempted to be answered are in fact very similar.

The lecture will examine the body of the colonized/migrant as a field of battle and resistance in real and metaphorical wars. Place where the stereotype is overthrown through a will for personal agency. Colonial space and the consequent postcolonial space is a hierarchical space where instruments of violence and oppression do not provide for the agency of the colonized subject or in the contemporary case of the migrant subject placed by power structures in a space of subalternity. But subjects are born free and though in a confined space seek their own path to freedom and awareness. In ways that are perhaps paradoxical in our eyes, but certainly effective in a very limited space granted. In the three lectures, through literary texts, three case studies related to as many books will be examined to understand precisely this tension between enclosed space and the search for freedom. A tension between (unjust) rules imposed, malevolent looks imposed and one's own body, one's own moral integrity.

Prerequisites / notice

This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

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Content

Corporate Sustainability is the flagship course of the Group for Sustainability and Technology at D-MTEC. In this course, students learn about key concepts in corporate sustainability and develop skills to implement them in the real world. The course prepares students for making well-informed sustainability decisions in their future careers.

The course uses constructive alignment to bring the various innovative teaching and learning elements (e.g., case-based experiential learning, reflective thinking and blended learning with videos and quizzes) into a coherent transformational journey. Students can now flexibly, efficiently, and effectively acquire the conceptual foundations that are essential for a substantial understanding of corporate sustainability.

For part of the course, students work in groups to complete a set of graded assignments designed to guide them into a deep dive on a selected corporate sustainability challenge. Please note that full participation in this part is essential, so make sure you are available. Furthermore, these group assignments count towards the overall grade for the course.

For further details on the course structure etc. visit the following link: http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Lecture notes

Presentation slides will be made available on Moodle after lectures.

Literature

Literature recommendations will be distributed via Moodle, and are available from the start of the course.

Prerequisites / notice

TEACHING FORMAT/ ATTENDANCE: The course includes several mandatory sessions that participants must attend to successfully earn credit points. It is not possible to take the class purely online.

Competencies

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<th>Competencies</th>
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<th>Method-specific Competencies</th>
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<td>and Self-reflection</td>
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363-0565-00L Principles of Macroeconomics

W 3 credits 2V J.-E. Sturm

Abstract

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes

The course Moodle page contains announcements, course information and lecture slides.

Literature


This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Competencies

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

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<th>Competencies</th>
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351-0555-00L Open- and User Innovation

W 3 credits 2G S. Häfliger, S. Spaeth

Abstract

This course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.

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Objective

The course includes both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active class participation is required.

Content

This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

Lecture notes

The slides are available and updated continuously through Moodle.

Literature

Relevant literature for the course includes slides and reading assignments. Papers will be made available through a corresponding Moodle group.

Competencies

- Subject-specific Competencies: 
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Problem-solving: assessed
- Social Competencies:
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: assessed
- Personal Competencies:
  - Creative Thinking: assessed
  - Critical Thinking: assessed

701-0747-00L Environmental Policy of Switzerland

Abstract

This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, assessed

Objective

Beyond acquiring basic knowledge about public policy analysis, this course teaches students how to analytically address current and concrete questions of environmental policy. Through exercises the students learn about political science concepts and frameworks as well as real-life political decision-making processes. The well-grounded examination of complex political conflict situations is an important precondition for the entry into the (environmental policy) workforce or a future research career.

Content

The processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

Lecture notes

The reader and additional lecture material and exercises will be posted on Moodle.

Literature

Reader and additional lecture material on moodle.

Prerequisites / notice

The detailed semester program (syllabus) is made available to the students at the beginning of the semester. During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture and to bring a laptop, tablet or smartphone to class, so that you can complete exercises using Moodle and eduApp.

Competencies

- Subject-specific Competencies: 
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Problem-solving: assessed
- Social Competencies:
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: assessed
- Personal Competencies:
  - Creative Thinking: assessed
  - Critical Thinking: assessed

351-1158-00L Economics

Abstract

This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

Objective

After successful completion of the course you will be able to:
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.
Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

Lecture notes
no script available

Literature

Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.
Globalization and technological progress in recent decades have on the one hand reduced inequality and led to new forms of inequality on the other hand. The question is whether these new forms of inequality lead to more inequality. This course provides an overview of the current philosophical and economic discourse on inequality and injustice.

Using philosophical and economic texts and discussions, students develop an understanding of the concepts, developments, causes, and consequences of inequality. Students will acquire the ability to participate in an informed discourse on the issues of inequality and injustice and to critically reflect on their actions and position in the world.

In this seminar we will explore the issues of inequality and injustice. In doing so, we will explore the following questions: What is meant by inequality and injustice? Under what circumstances are inequalities unjust? Have inequalities and injustices increased or decreased over the last 50 years? What are the causes of increasing or decreasing inequality? What do these inequalities and injustices mean for our society? And what public and private measures are needed for more inclusive societies?

- Concepts of inequality and injustice
- Development of inequality over the last 50 years based on different dimensions of inequality: income, wealth, education, health, CO2 emissions, political participation.
- Discrimination of women, people with physical disabilities, people of the "Global South".
- Causes of inequality: globalization, technological progress, political systems and institutions, economic system, social discrimination, stereotypes and norms.
- Consequences of inequality: justice, dignity, inefficiency
- Towards more inclusive societies: the role of policies, civil society, social movements and individual behavior.

The seminar is based on readings of economic and philosophical texts and is complemented by short presentations and discussions with scholars of philosophy and economics. In some cases, practitioners will also be invited to the seminar. Students will apply the concepts, theories and knowledge covered in the course to practical issues related to inequality and inequity.

<table>
<thead>
<tr>
<th>851-0685-00L Data and Society</th>
<th>W 3 credits 2V M. Leese</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>This lecture series explores the multifaceted role of data in shaping contemporary society, governance, and individual lives. The course equips students with a critical understanding of how data is made, managed, and preserved, and its implications for societal norms and individual rights.</td>
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<tr>
<td>Objective</td>
<td>At the end of the term, students will be able to:</td>
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<td>• reflect concepts and theories that capture the performativity of data</td>
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<td>• reflect concepts and theories that capture the socio-technical nature of data</td>
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<td>• assess the implications of data practices for social and political ordering</td>
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<td>• identify key actors, sites, and domain contexts of data practices</td>
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<td>Competencies</td>
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<td>Analytical Competencies fostered</td>
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<td>Self-awareness and Self-reflection fostered</td>
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<tr>
<th>851-0226-00L Postcolonial Readings</th>
<th>W 3 credits 2V I. Scego</th>
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<tr>
<td>Abstract</td>
<td>The history of colonialism in the modern age begins with Christopher Columbus who, as Todorov has well told us, did not &quot;discover&quot; anything, but crossed the Ocean in search of riches, bringing with him a baggage of violence, stereotypes and violent conquest of resources and bodies. And from here, from that 1492, the story became one of blood and struggle.</td>
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<td>The lecture will examine the body of the colonized/migrant as a field of battle and resistance in real and metaphorical wars. Place where the stereotype is overthrown through a will for personal agency. Colonial space and the consequent postcolonial space is a hierarchical space where instruments of violence and oppression do not provide for the agency of the colonized subject or in the contemporary case of the migrant subject placed by power structures in a space of subalternity. But subjects are born free and though in a confined space seek their own path to freedom and awareness. In ways that are perhaps paradoxical in our eyes, but certainly effective in a very limited space granted. In the three lectures, through literary texts, three case studies related to as many books will be examined to understand precisely this tension between enclosed space and the search for freedom. A tension between (unjust) rules imposed, malevolent looks imposed and one's own body, one's own moral integrity.</td>
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<td>3</td>
<td>2V</td>
<td>University lecturers</td>
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<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student</td>
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<td>UZH Module Code: 07S3EEE2266</td>
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Rationality has been treated as a “universal” character of human beings. But such understandings, though dominant, also came under androcentric and Eurocentric critique. Such reflections fostered the pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Ethics of Life Sciences and Biotechnology

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objectives

A. Identify ethical issues in in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: fostered
- Problem-solving: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
In this seminar we will explore the issues of inequality and injustice. In doing so, we will explore the following questions: What is meant by inequality and injustice? Under what circumstances are inequalities unjust? Have inequalities and injustices increased or decreased over the last 50 years? What are the causes of increasing or decreasing inequality? What do these inequalities and injustices mean for our society? And what public and private measures are needed for more inclusive societies?

- Concepts of inequality and injustice
- Development of inequality over the last 50 years based on different dimensions of inequality: income, wealth, education, health, CO2 emissions, political participation.
- Discrimination of people with physical disabilities, people of the “Global South”.
- Causes of inequality: globalization, technological progress, political systems and institutions, economic system, social discrimination, stereotypes and norms.
- Consequences of inequality: justice, dignity, inefficiency
- Towards more inclusive societies: the role of policies, civil society, social movements and individual behavior.

The seminar is based on readings of economic and philosophical texts and is complemented by short presentations and discussions with scholars of philosophy and economics. In some cases, practitioners will also be invited to the seminar. Students will apply the concepts, theories and knowledge covered in the course to practical issues related to inequality and inequity.
Fostered

T. Lobo

2G

Ethics of Building

Concepts and Theories

At the end of the term, students will be able to:

- reflect concepts and theories that capture the performative nature of data
- reflect concepts and theories that capture the socio-technical nature of data
- assess the implications of data practices for social and political ordering
- identify key actors, sites, and domain contexts of data practices.

Subject-specific Competencies

Method-specific Competencies

Social Competencies

Communication

Perspective Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Self-awareness and Self-reflection

At the end of the term, students will be able to:

- foster an overview of different historical and contemporary approaches in bioethics. They are enabled to further developing their
- foster their ability to understand complex theories, to critically reflect on them and to put them up for discussion.
- foster the ability to analyze the construction of a building, a district or a city. The seminar includes a student-co-led expedition through Zurich.

851-0038-00L

Philosophical Ethics of Life and Death

W

3 credits

2G

N. Mazouz

Abstract

Students will get an overview of different historical and contemporary approaches in bioethics. They are enabled to further developing their

Content

Bioethics is a very broad field, encompassing ethical issues relating to life and death, e.g. reproductive technology, euthanasia, organ transplantation, genetic engineering, animal and nature conservation, human enhancement, animal welfare, nature conservation, biodiversity and our relation to nature more generally. Bioethics is addressed in various contexts and disciplines, in politics, in law, in religious contexts, in the social sciences, religious studies, medicine and the biosciences. The focus in this course is on the fundamental debates in ethics as a philosophical discipline. In addition, topics are

Literature


Competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Problem-solving

Social Competencies

Communication

Sensitivity to Diversity

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Self-awareness and Self-reflection

851-0037-00L

Ethics of Building

W

3 credits

2S

T. Lobo

Abstract

Building practices have often been associated with utopian visions and promises of a more just way of living together. But to what extent can the built environment contribute to a better society? What role can mathematical models or data analyses play in questions of distributive justice in the city? Is it ever possible to build sustainably, or is building always also destroying the environment?

Objective

Students will learn about contemporary debates in architectural and urban planning ethics. We will discuss the positions against the background of their historical predecessors and current contexts. Students will work on small case studies in which they will ethically analyze the construction of a building, a district or a city. The seminar includes a student-co-led expedition through Zurich.

Content

Throughout history, there have always been utopian visions and promises tied to construction, be it of individual objects, such as towers, or of entire cities. For example, thanks to their geometric shapes, modern cities are supposed to enable more equality among people, even the equal distribution of sunshine, as Le Corbusier once dreamed. But to what extent is it even possible to create more equality by designing living spaces? A wall automatically excludes by protecting the interior. Building cities always means defining the far and the near, the center and the periphery, the upper and the lower. These orientations translate into social relations for example of those who have to commute far and those who are at the center of the action. Who determines how and what is built and whose perspective is not taken into account? To whom does a built landscape afford agency and to whom not? Mathematical models can predict the probabilities of encounters in space, which also can have an impact on social relationships. What is the relevance of such models as well as the more recent data analyses in questions of distributive justice? Is it possible to distribute social participation in the city? Does construction always have to destroy and replace the underlying nature? How do our building practices affect coexistence with other species?

We will not be able to solve these problems in one semester, but we will intensively grapple with the overarching question implied in all of them. The question is on the extent to which the built environment takes on ethical significance for human (and other) forms of life, and how are we to understand ethics in general if it is to respond to such questions.

Competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Project Management

Social Competencies

Communication

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

851-0186-00L

Feminist and New Materialist Philosophies of Science and Technology

W

3 credits

2S

R. Wagner

Abstract

This course will present an overview of feminist philosophies of science and technology and new materialist philosophies of science and technology.

Objective

The students will be able to analyze techno-scientific knowledge and practices from the point of view of various recent philosophical frameworks from the context of feminist and new materialist philosophy.

Content

The course will cover feminist approaches to empiricism, to the question of fact/value and to the re-articulation of the concept of objectivity. It will also cover new materialist approaches, such as those of Bennett, Barad and Latour. The discussion will be related to the science-technology-politics nexus, and evaluated critically.
Participants should acquire knowledge about how to characterize complex systems adequately, to be aware of the problems involved in their prediction and control, and to apply their knowledge in an interdisciplinary context.

Basic concepts for the treatment of complex systems are state spaces, observables, partitions, dynamics, stability, and information. They are introduced in general and concretized by means of examples. Furthermore, various definitions of complexity are introduced, which are linked to concepts such as emergence, meaning, non-commutative observables, and scaling laws. Finally, different types of networks are discussed, as well as learning processes and other types of dynamics in such networks.

In the course we read classical texts from the field of philosophy of war (Clausewitz, Sun Tzu, Tolstoy, Machiavelli, Kant) and focus on questions such as: what is war? Strategy and tactics in war? Ethics of war? War and Politics?

This course introduces students to the ethical, political and legal debates and transformations in relation to Artificial Intelligence and provides students with concepts and methods from the constructivist and interpretive social sciences to work towards responsible and democratic human-technology futures. Particularly suitable for students D-CHAB, D-INFK, D-ITET, D-MATH, D-PHYS.

The main objectives of the course are to enable students to 1) identify the ways in which human values and developments of AI technologies are entangled, 2) articulate what is significant about contemporary transformations in AI and society, and 3) participate and shape the relationship between human values and AI as citizens and professionals.

The growing presence of AI tools for public use, for public administration, inside corporations and in scientific research raises many questions about the ethical, political, legal consequences of these technologies. This course is built around multiple sites of encounter among human values and AI, including bodies, persons, cities, labs, law, and environment. In each site, we inquire about what and whose values are being prioritized and with what consequences. The course also investigates existing best-practices around how to "align" human values with AI (e.g. human-centric design, alignment, reproducibility, transparency, explainability) and introduces students to regimes of ethics and governance of AI being proposed in jurisdictions around the world. Students learn to unpack the values and assumptions in existing theories and frameworks for the design and governance of AI and to engage constructively with diverse stakeholders to shape the human-technology future towards aims that are reflexive, responsible, and democratic.
Engineers and scientists often pursue their studies and research in the hope that their knowledge can contribute to make a better world, inform democratic deliberation and help public understanding of complex issues. Yet this special status of science and technology is being increasingly contested by marginalized publics, lobbies, exposed populations, and by members of the scientific communities themselves. Climate skepticism or vaccine hesitancy are some of the most vivid examples of this confusing situation. In this seminar, students will learn to reflect on expertise as a form of scientific engagement in the messiness of democratic deliberation and public life, beyond the noble but outdated ideal of “speaking truth to power”.

The exercise of expertise is stumbling upon several conundrums. Which knowledge is relevant in which situation? How to make sure that some crucial perspectives are not left out in the shadows? How to identify representative experts and make sure that they speak on behalf of a structured community? Whose voices are being silenced? On the other side of the street, the public is often said to lack proper understanding of science and thus in need of being educated or disciplined. Or is it suspected of being manipulated by lobbies or foreign hostile powers, or of being too attached to its own privileges and unwilling to act in favor of the common good. Whose agency is being acknowledged in sociotechnical controversies and whose agency is being denied and why? The seminar will provide a deep understanding of these perspectives, by putting them in a broader historical and epistemological context. Students will thus learn to critically assess their strengths as well as their blind spots.

Whereas opposing technological developments (anti 5G or anti-vaccine activists) or pushing to act accordingly to science (pro climate movements such as Extinction Rebellion or Scientist Rebellion), activists’ movements make up for a rich field of investigation on the dynamics of expertise’s texts and scientists themselves. The seminar will focus on scientists’ narratives, their interactions and the ways in which they articulate their expertise in the face of public or more scientific discourses.

The seminar will thereby take into account both historical and contemporary cases of sociotechnical controversies, and discuss them by applying the techniques of ethnography and science and technology studies (STS). The seminar will explore the attitudes and roles of different concepts at play in scientific controversies, such as the “public”, the “expert”, the “citizen” or the “actor”.

Social and economic aspects will be discussed. How are scientific controversies for instance related to social movements? How do they impact on the way people participate in them?

The seminar is aimed at students who would like to develop their analytical capacities in order to critically assess the expertise and knowledge at stake in sociotechnical controversies.

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection

Method-specific Competencies

- Decision-making
- Problem-solving
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management
Concepts and Theories

Analytical Competencies

The main objective of this seminar is to gain an in-depth understanding of the recent literature on understanding in the philosophy of science, the philosophy of mathematics, and epistemology. Another practical objective is to increase your skills in giving clear and engaging oral presentations.

Content

Understanding is a central goal of science and mathematics, but what exactly is the nature of scientific and mathematical understanding? In this seminar, we will read and discuss a number of key philosophical contributions on understanding in philosophy of science, philosophy of mathematics, and epistemology. You will also practice your skills in giving clear and engaging oral presentations.

To this end, we will read a number of key philosophical contributions on understanding in philosophy of science, philosophy of mathematics, and epistemology. Along the way, we will address general issues on understanding such as: What is the relation between understanding and knowledge? Does understanding necessarily require explanation? How can understanding be transmitted? What exactly is the value of understanding? We will also look into specific case studies of scientific and mathematical understanding.

Each session will be decomposed into three blocks. In blocks 1 and 2, we will have a short presentation (~15 minutes) of a contribution in the philosophy of understanding followed by a discussion. Block 3 will be methodological and will be concerned with how to give good oral presentations, an essential skill in academia. We will use this block to debrief on the presentations of the day and see how they could be improved. We will also discuss resources on best practices in oral communication.

851-0026-00L

Postcolonial Readings

W 3 credits 2V 1. Sciogi

Abstract

The history of colonialism in the modern age begins with Christopher Columbus who, as Todvor has well told us, did not "discover" anything, but crossed the Ocean in search of riches, bringing with him a baggage of violence, stereotypes and violent conquest of resources and bodies. And from here, from that year, 1492, the story became one of blood and struggle.

Objective

The course will be based on case studies, linked to national realities (Brazil, Senegal, Eritrea, Great Britain, Italy, Peru, Somalia, etc.) and to physical places (the front, the museum, the field, the street, the body), to see how in different contexts, despite the peculiarity of the context, the dilemmas that are attempted to be answered are in fact very similar.

Content

WE are here, because YOU have been there, have you ever heard that phrase? In a university lecture hall? In an anti-racist demonstration? In a play? In a discussion on the bus? The YOU represents Europe and in a broader sense the West, the WE the peoples who suffered colonization by the very West that portrayed itself as a beacon of civilization. The history of colonialism in the modern age begins with Christopher Columbus who, as Todvor has well told us, did not "discover" anything, but crossed the Ocean in search of riches, bringing with him a baggage of violence, stereotypes and violent conquest of resources and bodies. And from here, from that 1492, the story became one of blood and struggle. It is a story that has covered a time span of nearly half a millennium, ranging from human trafficking to the extractive, and accumulation, policies of our contemporary times. The consequences of all this violence are steadily still visible on the body of the world, open wounds that bleed. Wounds in which lurk prejudice, systemic racism and murder.

To examine these consequences, to understand how contemporary societies in the global north and south, are still torn apart by this history that never seems to pass; we will rely on literature, on "postcolonial" texts that will show us the complexity of what exists. The course will be based on case studies, linked to national realities (Brazil, Senegal, Eritrea, Great Britain, Italy, Peru, Somalia, etc.) and to physical places (the front, the museum, the field, the street, the body), to see how in different contexts, despite the peculiarity of the context, the dilemmas that are attempted to be answered are in fact very similar.

The lecture will examine the body of the colonized/migrant as a field of battle and resistance in real and metaphorical wars. Place where the stereotype is overthrown through a will for personal agency. Colonial space and the consequent postcolonial space is a hierarchical space where instruments of violence and oppression do not provide for the agency of the colonized subject or in the contemporary case of the migrant subject placed by power structures in a space of subalternity. But subjects are born free and though in a confined space seek their own path to freedom and awareness. In ways that are perhaps paradoxical in our eyes, but certainly effective in a very limited space granted. In the three lectures, through literary texts, three case studies related to as many books will be examined to understand precisely this tension between enclosed space and the search for freedom. A tension between (unjust) rules imposed, malevolent looks imposed and one's own body, one's own moral integrity.

Political Science

Number Title Type ECTS Hours Lecturers
853-0038-00L Swiss Foreign Policy W 3 credits 2V D. Möckli Weder

Abstract

This course analyzes the foundations and challenges of Swiss foreign policy. After reviewing the history of foreign policy conceptions since the early 20th century, we will discuss the determining factors of Swiss foreign policy and examine, together with guest speakers from the foreign ministry, current international developments and respective foreign policy challenges.

Objective


Content

In this seminar, we will discuss the origins of the modern nation-state and its relationship to the contemporary world order. We will examine the role of Swiss foreign policy in shaping the international system, and the challenges it faces in the current geopolitical landscape.

Lecture notes

Prerequisites / notice

The course will be supported by an e-learning environment.

Competencies

Subject-specific Competencies

Concepts and Theories

Analytical Competencies

Decision-making

Social Competencies

Cooperation and Teamwork

Personal Competencies

Critical Thinking

853-0047-01L World Politics Since 1945: The History of International Relations (Without Exercises)

W 3 credits 2V A. Wenger

Abstract

This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91, the focus here is on current issues in international security policy.
Objective By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations since the end of the Second World War.

Content cf. “Diploma Supplement”

Prerequisites / notice The lecture is being supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch)

Competencies | Subject-specific Competencies | Concepts and Theories | assessed
---|---|---|---
Method-specific Competencies | Analytical Competencies | assessed
Decision-making | assessed
Problem-solving | assessed
Social Competencies | Communication | fostered
Leadership and Responsibility | fostered
Sensitivity to Diversity | fostered
Negotiation | assessed
Personal Competencies | Creative Thinking | fostered
Critical Thinking | fostered

853-0015-01L Conflict Research I: Political Violence | W | 3 credits | 2V | A. Juon

Abstract Introduction to research on political violence in domestic and international politics. This course covers the causes and solutions to different types of political violence including interstate wars, civil wars, terrorism or social protests.

Objective Knowledge on different types of political violence and their causes.

Content This course offers an introduction to research on the causes and solutions to political violence in domestic and international politics. First, we discuss the definitions and concepts used in conflict research, the data and methods commonly applied and their historical development. Second, we focus on interstate wars and examine in this context state formation, nationalism and democracy. The third part of the course focuses on different types of political violence, including civil war, terrorism or social protests.

Prerequisites / notice The course «Conflict Research II» in the following semester further examines civil wars.

853-0302-01L European Integration (Seminar without Tutorial) | W | 2 credits | 2S | C. Freudlsperger

Abstract The lecture course covers the theory, development, and core policy fields of European integration as well as structures and processes of the EU as a decision- and policy-making system.

Objective The seminar is designed to help students understand the European Union as a particular kind of political system that differs both from the nation-state and from other international organizations. It imparts basic knowledge on the development, institutions, procedures, and policies of the EU and provides an introduction to major approaches to integration theory and political science research on the EU.


Lecture notes The seminar covers the theory, development, and core policy fields of European integration as well as structures and processes of the EU as a decision- and policy-making system.

Literature Die Literatur wird auf Moodle bereitgestellt.

The grade is based on a written exam.

Competencies | Subject-specific Competencies | Concepts and Theories | assessed
---|---|---|---
Method-specific Competencies | Analytical Competencies | assessed
Personal Competencies | Critical Thinking | assessed

860-0023-00L International Environmental Politics | W | 3 credits | 2V | T. Bernauer

Abstract This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined.

Objective The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

Content This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

Lecture notes Reading materials and slides will be available via Moodle.

Literature Reading materials and slides will be available via Moodle.
We start with an overview of cybersecurity issues from 1980 to today and look at events and actors responsible for turning cybersecurity into a security policy concern. The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures).

The lecture is being supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch).

The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

The lecture is being supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch).

Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts. The lecture is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy.

The lecture is being supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch).

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In this course students deepen their knowledge about global development and sustainability issues. We will show five movies each of them linked to one of the five P’s (Planet, People, Prosperity, Peace and Partnerships) reflecting the topics of the 2030 Agenda. Afterwards the movie will be critically discussed with researchers and relevant stakeholders from the broader society.

- Students get a broad understanding of some of the most important issues and discussions related to sustainable development.
- Students get exposed to diverse realities of young people in developing countries.
- Students can critically reflect upon the information that is presented to them in the movies and relate it to the broader discussions around sustainable development.
- Students reflect on issues concerning communicating research and the realities of low-income settings to a wider public.

The aim of the course is to deepen student’s knowledge about global issues and to inspire them to reflect critically upon complex topics, which are related to the broader discourse on sustainable development. In each class, we show a documentary film, which is linked to one of the five critical areas of the 2030 Agenda (Planet, People, Prosperity, Peace and Partnerships), putting specific focus on realities in developing countries. Following the movie screenings, we will discuss the topic of the film in the light of sustainable development with an expert from academia and/or a practitioner from the field of development cooperation. In preparation for each class, the students read an academic paper, which will also be considered in the discussion. The idea of “Bridging Art and Science” is to expose an interdisciplinary group of students to artistic and scientific perspectives alike and to challenge them to deal with bias and polarization, and the role that the media and films play in that regard. The participants of the course will be given the chance to embrace the complexity of sustainable global development.

The Sustainable Development Goals in Context

The United Nations Agenda 2030 and its 17 Sustainable Development Goals (SDGs) provide an opportunity for the international community to shape the course of sustainable development. The lectures center on 17 sustainability and equity challenges and provide insights from researchers as well as decision makers from policy, the private sector and civil society.

- Students know important dimensions of sustainable development and the discourse in the context of the SDGs.
- Students get an overview how ETH Zurich contributes to sustainable development and the achievement of the SDGs.
- The lecture series enables students to contribute to sustainable development during their studies and research, as graduates on the job market, and as members of the society.
- Writing a short blog post trains students to communicate acquired knowledge effectively for a broader audience.
- Students will learn to critically read short articles and ask follow-up questions to experts of a field.

For each lecture we will invite one researcher or one decision maker from policy, the private sector or civil society to reflect on one particular SDG. These talks will be followed by discussions with students and the general public. Majority of the lectures and discussion sessions will be held on campus, and some sessions online.

Open to advanced Bachelor and all Master level students enrolled at ETH Zurich

This lecture series explores the multifaceted role of data in shaping contemporary society, governance, and individual lives. The course equips students with a critical understanding of how data is made, managed, and preserved, and its implications for societal norms and individual rights.

- Students get an overview how ETH Zurich contributes to sustainable development and the achievement of the SDGs.
- Students know important dimensions of sustainable development and the discourse in the context of the SDGs.
- The lecture series enables students to contribute to sustainable development during their studies and research, as graduates on the job market, and as members of the society.
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Open to advanced Bachelor and all Master level students enrolled at ETH Zurich

The course read classical texts from the field of philosophy of war (Clausewitz, Sun Tzu, Tolstoy, Machiavelli, Kant) and focus on questions such as: What is war? Strategy and tactics in war? Ethics of war? War and Politics?

In the course we read classical texts from the field of philosophy of war (Clausewitz, Sun Tzu, Tolstoy, Machiavelli, Kant) and focus on questions such as: What is war? Strategy and tactics in war? Ethics of war? War and Politics?

The seminar aims to inspire a nuanced understanding of the dynamics of expertise in society. Cross-fertilizing literature from science and technology studies (STS) and from activists’ movements, it focuses on contemporary controversies around emerging technologies and climate policy, where trust in science is said to be undermined (e.g. climate skepticism or anti-vaccine movements).

1. Introduce to the role and functions of expertise in democratic societies.
2. Familiarize with assumptions about science and society embedded in contemporary controversies.
3. Inspire critical perspectives on (dis)trust in science through activists’ movements on contested environmental and technological issues.
4. Develop a creative position on the relations between science, trust and politics.
Lecturers
2G
E. Stern
I. Scego

1. Introduction: International Humanitarian Law IHL 101; International Committee of the Red Cross ICRC's perspective; Terminology.

2. Digital Technologies and Armed Conflict

3. Connectivity in Crisis: No connectivity: the connectivity gap; Loss or limitation of connectivity; Stable connectivity: connected in crisis.

4. Hybrid and Unconventional Warfare: Kinetic and cyber offensive operation coordination; Disruption of digital services; The dual-use dilemma; The public-private partnership dilemma: Civilization of digital warfare, Total offense and whole-of-societies: a digital perspective of society's active participation; The cognitive warfare: a digital perspective of modern low-intensity constant warfare.

5. The Potential Human Cost of Cyber Operations.


7. Case Studies (based on scenarios).

Engineers and scientists often pursue their studies and research in the hope that their knowledge can contribute to make a better world, to examine these consequences, to understand how contemporary societies in the global north and south, are still torn apart by this history of colonialism in the modern age that never seems to pass; we will rely on literature, on “postcolonial” texts that will show us the complexity of what exists. The course will be organized as a structured conversation and a collective mapping of actors and key concepts of sociotechnical controversies. Over the course of the semester, students will learn not only to navigate some of the most heated contemporary debates, but also to articulate their own position on an issue of their choice.

Students will focus on the implications for tech companies, understanding the new challenges from a technological, policy and legal perspective.

Students will learn how digital technologies are impacting modern conflicts and what are the actual and future trends in this domain.

Content
Engineers and scientists often pursue their studies and research in the hope that their knowledge can contribute to make a better world, to examine these consequences, to understand how contemporary societies in the global north and south, are still torn apart by this history of colonialism in the modern age that never seems to pass; we will rely on literature, on “postcolonial” texts that will show us the complexity of what exists. The course will be organized as a structured conversation and a collective mapping of actors and key concepts of sociotechnical controversies. Over the course of the semester, students will learn not only to navigate some of the most heated contemporary debates, but also to articulate their own position on an issue of their choice.

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871-0240-00L
Human Learning (EVi)

This lecture is only apt for students who intend to enrol in the programs “Teaching Diploma” or “Teaching Certificate”. It is about learning in childhood and...
This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Thematical Schwerpunkte:
Lernen als Verhaltensänderung und als Informationsverarbeitung; Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Folien werden zur Verfügung gestellt.

This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability, with a focus on Creative Thinking assessed, G. Grote, Folien werden zur Verfügung gestellt.

Folien werden zur Verfügung gestellt.

3S
3 credits

Fostering

The main goals are:
(1) You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
(2) You have a basic understanding about psychological test theory and can appropriately administer tests.
(3) You know various techniques of formative assessment and can apply these to uncover students’ misconceptions.

Support and Diagnosis of Knowledge Acquisition W 3 credits 3S C. M. Thurn, S. Daguati

Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the “Teaching Diploma”.

Prerequisites: successful participation in 871-0240-00L “Human Learning (EW1)”.

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

The main goals are:
(1) You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
(2) You have a basic understanding about psychological test theory and can appropriately administer tests.
(3) You know various techniques of formative assessment and can apply these to uncover students’ misconceptions.

Prerequisites / notice

This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

871-0238-01L

Human-Computer Interaction: Cognition and Usability W 3 credits 2S C. Hölscher, I. Barisic, B. Davison

Particularly suitable for students of D-ARCH, D-INFK, D-ITET.

This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability, with a focus on applying them to real situations.

Presentations will cover the basics of human-computer interaction and selected topics:
● History of HCI
● Research ethics
● Literature reviews
● Participant-free methods: cognitive walkthrough and heuristic evaluation
● Card sorting and information architecture
● Usability studies
● Unmoderated research and diary studies
● Surveys
● User Logs and metric frameworks

On a weekly basis, students will conduct authentic research in class covering the topics above. They will submit their in-class research results regularly and also present their findings to the class once per semester.

The final project demonstrates class topic adoption by deeply exploring one HCI problem using the covered methods and tools. Students will choose a research topic and execute their research plan. They will individually write a formal report including problem definition, literature review, methodology, findings and discussion.

363-0311-00L

Psychological Aspects of Risk Management and Technology W 3 credits 2V N. Bienefeld-Seall, G. Grote, R. Schneider, M. Zumbühl

Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are put in a position where they can further educate themselves in the field of research into teaching and learning.

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Thematical Schwerpunkte:
Lernen als Verhaltensänderung und als Informationsverarbeitung; Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Folien werden zur Verfügung gestellt.

This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability, with a focus on Creative Thinking assessed, G. Grote, Folien werden zur Verfügung gestellt.

Folien werden zur Verfügung gestellt.

3S
3 credits

Fostering

The main goals are:
(1) You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
(2) You have a basic understanding about psychological test theory and can appropriately administer tests.
(3) You know various techniques of formative assessment and can apply these to uncover students’ misconceptions.

Support and Diagnosis of Knowledge Acquisition W 3 credits 3S C. M. Thurn, S. Daguati

Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the “Teaching Diploma”.

Prerequisites: successful participation in 871-0240-00L “Human Learning (EW1)”.

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

The main goals are:
(1) You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
(2) You have a basic understanding about psychological test theory and can appropriately administer tests.
(3) You know various techniques of formative assessment and can apply these to uncover students’ misconceptions.

Prerequisites / notice

This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

871-0238-01L

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This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability, with a focus on applying them to real situations.

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● History of HCI
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The final project demonstrates class topic adoption by deeply exploring one HCI problem using the covered methods and tools. Students will choose a research topic and execute their research plan. They will individually write a formal report including problem definition, literature review, methodology, findings and discussion.

363-0311-00L

Psychological Aspects of Risk Management and Technology W 3 credits 2V N. Bienefeld-Seall, G. Grote, R. Schneider, M. Zumbühl

Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are put in a position where they can further educate themselves in the field of research into teaching and learning.
Objective

- You know how risk and risk management is defined and applied in different industries
- You know the challenges of decision making under risk and uncertainty and its effects on organisations
- Know about and (partially) apply some risk management tools
- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

This course consists of three main elements:

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).

Content

The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations.

Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication

- Psychological and organizational concepts relevant in risk management
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

- Group projects related to company case studies

Lecture notes

There is no script, but slides will be made available before the lectures.

Literature

There are texts for each of the course topics made available before the lectures.

Prerequisites / notice

The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

Competencies

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<th>Subject-specific Competencies</th>
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701-0721-00L Psychology

W 3 credits 2V R. Hansmann, A. Bearth, M. Siegrist

Abstract

This course provides an introduction to psychological research and modelling, focusing on cognitive psychology and the psychological experiment. Participants learn to formulate problems for psychological investigation and apply basic forms of psychological experiment.

Objective

Students are able to
- describe the areas, concepts, theories, methods and findings of psychology.
- differentiate scientific psychology from "everyday" psychology.
- structure the conclusions and significance of an experiment, according to a theory of psychology.
- formulate a problem for psychological investigation.
- apply basic forms of psychological experiment.

Content

Einführung in die psychologische Forschung und Modellbildung unter besonderer Berücksichtigung der kognitiven Psychologie und des psychologischen Experiments. Themen sind u.a.: Wahrnehmung; Lernen und Entwicklung; Denken und Problemlösen; Kognitive Sozialpsychologie; Risiko und Entscheidung.
Focus on the Human: Human-Centered Security and Privacy Lab

The course is particularly suitable for all students who have already completed the course “Human-centered IT Security and Privacy” as some of the concepts introduced will practically be applied in this course. However, the relevant literature and necessary material will be provided to all students and basic concepts will be briefly summarized so that all interested students can participate.

After an introduction on usable security as the intersection of computer science and psychology, students will form teams and work on exemplary security- or privacy-related research questions. The teams will develop and evaluate a concept for a human-centered solution. Through input sessions and milestone presentations the human perspective will be incorporated and reflected upon.

The course makes students experience an exemplary human-centered design process. They will learn about and practically apply human-centered design and evaluation methods that will allow them to view their solution from the human perspective, e.g., the user, developer or website owner perspective. By taking part in the evaluation of other teams, they will also take the user perspective themselves.

At the beginning of the course, the students will receive an introduction to usable IT security and privacy and relevant concepts. Afterwards, a selection of current research questions from that area will be presented. The students form teams and select one of the proposed research questions. This question will accompany the students throughout the semester. They will design and evaluate a concept for a human-centered solution to that question. To be able to do so, they will receive input on human-centered design and evaluation tools. Their progress and the inclusion of the human perspective will be subject to feedback in milestone presentations.

The students’ human-centered solution can take the form of a concept (e.g., a concept for a product or app), interface (e.g., a visual or tangible interface), or prototype (e.g., sketches, a click-dummy or a built prototype). The solution will then be subject to evaluations. The solutions will be user-tested by members of other teams that thereby take the perspective of a user themselves. In addition, the solutions will be analyzed from different stakeholders’ perspectives, such as developers or website owners.

Finally, the students will reflect on potential changes that results from the evaluations and their consequences.

851-0252-08L Evidence-Based Design: Methods and Tools for Evaluating Architectural Design

This course will be particularly suitable for students of D-ARCH.

Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

851-0253-08L Advanced Topics in Evidence-Based Design for Architecture

Course requirements: Completion of the course Evidence-Based Design: Methods and Tools For Evaluating Architectural Design (851-0252-08L).

Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layouts from the perspective of end-users.

Students will build on their previous projects as part of the course "Evidence-Based Design: Methods and Tools For Evaluating Architectural Design" (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University Designing the post-pandemic hospital with evidence. For people. The course is funded by an ETH innovedum project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

851-0391-00L Focus on the Human: Human-Centered Security and Privacy Lab

The course is particularly suitable for all students who have already completed the course “Human-centered IT Security and Privacy” as some of the concepts introduced will practically be applied in this course. However, the relevant literature and necessary material will be provided to all students and basic concepts will be briefly summarized so that all interested students can participate.

After an introduction on usable security as the intersection of computer science and psychology, students will form teams and work on exemplary security- or privacy-related research questions. The teams will develop and evaluate a concept for a human-centered solution. Through input sessions and milestone presentations the human perspective will be incorporated and reflected upon.

The course makes students experience an exemplary human-centered design process. They will learn about and practically apply human-centered design and evaluation methods that will allow them to view their solution from the human perspective, e.g., the user, developer or website owner perspective. By taking part in the evaluation of other teams, they will also take the user perspective themselves.

At the beginning of the course, the students will receive an introduction to usable IT security and privacy and relevant concepts. Afterwards, a selection of current research questions from that area will be presented. The students form teams and select one of the proposed research questions. This question will accompany the students throughout the semester. They will design and evaluate a concept for a human-centered solution to that question. To be able to do so, they will receive input on human-centered design and evaluation tools. Their progress and the inclusion of the human perspective will be subject to feedback in milestone presentations.

The students’ human-centered solution can take the form of a concept (e.g., a concept for a product or app), interface (e.g., a visual or tangible interface), or prototype (e.g., sketches, a click-dummy or a built prototype). The solution will then be subject to evaluations. The solutions will be user-tested by members of other teams that thereby take the perspective of a user themselves. In addition, the solutions will be analyzed from different stakeholders’ perspectives, such as developers or website owners.

Finally, the students will reflect on potential changes that results from the evaluations and their consequences.
This lecture series covers psychedelic science mainly psychologically, and additionally pharmacologically, physiologically, and ethically approved studies where these substances are administered to medically screened, prepared, and supported participants.

This course is especially recommended after the related lecture "851-0390-00 G Human-Centered IT Security and Privacy". However, previous participation in the lecture is not a requirement and not necessary for succeeding in the course.

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**
- Communication: fostered
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Sensitivity to Diversity: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

**Literature Recommendations:**

**Prerequisites / notice**
- This course is especially recommended after the related lecture "851-0390-00 G Human-Centered IT Security and Privacy". However, previous participation in the lecture is not a requirement and not necessary for succeeding in the course.

**Literature**

**Competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**
- Communication: fostered
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Sensitivity to Diversity: fostered

**Personal Competencies**
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered

**Literature Recommendations:**
### Analytical Competencies

In this seminar, we consider how the human brain processes social information. The approach focuses on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies from atypical populations, whose pathologies are typified by dysfunction in social information processing, such as autism spectrum disorder and schizophrenia.

- To familiarise students with forms of social cognition in humans, as well as the neural systems that support social cognition.

- To critically evaluate theories and data relating to Social Cognition and Social Neuroscience.

- To relate how knowledge of typical brain function can inform our understanding of individuals who process social information differently, and vice versa.

- To develop effective scientific communication skills in oral and written formats.

### Content

This seminar will consider how the human brain understands and organises social behaviour. The approach will focus on exploring the neural bases of social cognition in healthy individuals, as well as providing case studies from atypical populations, whose pathologies are typified by dysfunction in social information processing. Examples of such pathologies include autism spectrum disorder, schizophrenia and attention deficit hyperactivity disorder. By examining healthy and atypical populations, this module will highlight how disorders of social cognition can inform the understanding of healthy brain function, as well as how understanding healthy brain function can inform disorders of social cognition.

#### Privacy Quantification and Usable Protection

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<td>N. Zufferey, V. Zimmermann</td>
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### Abstract

Students will gain an overview of the main privacy metrics that are used to evaluate privacy risks related to the use of a given technology. They will also be introduced to the concepts of privacy/utility balance and usable security. Practical exercises and reading of recently published scientific articles will be used to present practical cases of the theoretical tools presented in class.

### Objective

This course aims to provide the students with a global knowledge of the concepts related to privacy, and the methodology and tools to identify, analyze, and address threats while taking the user into account in the process. They will adopt a “privacy mindset”, thus enabling them to act ethically and responsibly in the design, development, and use of systems and services.

### Content

First, the course will introduce the different definitions and approaches of privacy (e.g., privacy by control, privacy by design) as well as the ethical concerns and considerations related to information security and privacy research (e.g., responsible disclosure, full disclosure).

Second, the students will be introduced to the different methods, properties, and metrics to assess and/or guarantee a certain level of privacy. They will be introduced to the properties and metrics related to anonymization (e.g., k-anonymity, l-diversity), data aggregation (e.g., randomized responses, ε-differential privacy), as well as other privacy assessment methodologies (e.g., inferential privacy).

Third, the course will address usability issues and the role of individuals (i.e., users) in privacy management (i.e., usable security and privacy) and the design of privacy-enhancing technologies. In this context, we will analyze the main concepts seen during the course and discuss their advantages and disadvantages in terms of usability, as well as their implementation for mass-market and large-scale technologies.

Across all three parts of the course, practical exercises, as well as recent research articles reading, and presentations will be used as a complement to support the concepts seen in class, as well as to provide concrete examples of methodologies related to the assessment of privacy in general.

### Literature


### Competencies

#### Subject-specific Competencies

- Techniques and Technologies: assessed

#### Method-specific Competencies

- Analytical Competencies: fostered

#### Social Competencies

- Communication: fostered

#### Personal Competencies

- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered

### Neuroaesthetics - Exploring the Science of Aesthetic Experience

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<td>E. Cross, I. Bara</td>
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### Abstract

This seminar introduces students to theory and research, challenges, and opportunities in neuroaesthetics, with a clear emphasis on the interdisciplinary nature of the discipline situated at the intersection of neuroscience, psychology, and art appreciation. Foundational empirical methods and critical perspectives of research approaches in neuroaesthetics are considered.

### Objective

- To familiarize students with concepts, models, methods, brain and behavioral findings related to aesthetic experience.

- To develop a critical understanding in evaluating the theoretical and empirical findings in neuroaesthetics.

- To integrate the acquired knowledge to critically debate and discuss the conceptual and empirical issues related to the science of aesthetic experience.

### Content

In this seminar, students will learn about the foundational principles of neuroaesthetics, which explores the cognitive and brain processes involved in aesthetic experience. A key focus will be placed on developing an appreciation of the interdisciplinary methods used in the neuroaesthetics field – ranging from neuroscience, psychology, philosophy, and art history. The seminar is based on the active engagement of students in reading, presenting, and critically discussing selected papers in the field. In a final small-group assignment, students are expected to incorporate and elaborate upon the content covered in the seminar by presenting and discussing a novel research proposal for tackling a timely research question related to aesthetic experience.
This seminar introduces the fundamentals and latest research developments of brain imaging in real-world contexts. We explore topics from imaging multiple people's brains simultaneously as they interact to neuro-ethics and neuro-art, while maintaining a strong focus on critical evaluation of research practices and applications of brain imaging of and during social interaction.

Rapid advances in the technologies and empirical approaches used in imaging the human brain have opened exciting windows into how the human brain coordinates social interaction. These advances include imaging the brain's function during real social interactions, training behaviours with feedback based on real-time brain activity, and even generating art directly from brain signals. With them, these advances have brought novel ethical implications regarding their implementation in research and potentially, their use by the public, for both therapeutic and possible "neurohacking" applications. In this seminar, students will be introduced to various neuroimaging approaches for social neuroscience generally, as well as to approaches for measuring social brain function in real life, and will gain insights into related ethical considerations.

The seminar builds on the active participation of students in reading, presenting, and critically discussing selected papers in the field. In a final small-group assignment, students are required to integrate and elaborate upon topics covered in the seminar by presenting and debating a novel research proposal for addressing a timely research question related to the use of brain imaging in the context of social interactions. No prior experience or knowledge in brain imaging is required.

Lecturers
S. Bechtold
E. Cross
R. Moffat

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851-0272-00L The Cutting Edge of Social Brain Imaging

W 2 credits 2S E. Cross, R. Moffat

Abstract
This seminar introduces the fundamentals and latest research developments of brain imaging in real-world contexts. We explore topics from imaging multiple people's brains simultaneously as they interact to neuro-ethics and neuro-art, while maintaining a strong focus on critical evaluation of research practices and applications of brain imaging of and during social interaction.

Objective
- To familiarize students with current concepts, theories, methods, and findings from social brain-imaging sciences
- To develop a critical view of extant findings and the tools for evaluating the quality of evidence and data, as well as ethical implications

Content
Rapid advances in the technologies and empirical approaches used in imaging the human brain have opened exciting windows into how the human brain coordinates social interaction. These advances include imaging the brain's function during real social interactions, training behaviours with feedback based on real-time brain activity, and even generating art directly from brain signals. With them, these advances have brought novel ethical implications regarding their implementation in research and potentially, their use by the public, for both therapeutic and possible "neurohacking" applications. In this seminar, students will be introduced to various neuroimaging approaches for social neuroscience generally, as well as to approaches for measuring social brain function in real life, and will gain insights into related ethical considerations.

The seminar builds on the active participation of students in reading, presenting, and critically discussing selected papers in the field. In a final small-group assignment, students are required to integrate and elaborate upon topics covered in the seminar by presenting and debating a novel research proposal for addressing a timely research question related to the use of brain imaging in the context of social interactions. No prior experience or knowledge in brain imaging is required.

Lecturers
S. Bechtold
E. Cross
R. Moffat

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0735-09L</td>
<td>Workshop &amp; Lecture Series on the Law &amp; Economics</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>S. Bechtold</td>
</tr>
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</table>

Abstract
This series is a joint project by ETH Zurich and the Universities of St. Gallen and Zurich. It provides an overview of interdisciplinary research on intellectual property, innovation, antitrust, privacy & technology policy. Scholars from law, economics, management and related fields present their current research. All speakers are internationally well-known experts from Europe, the U.S. & beyond.

Objective
After the workshop and lecture series, participants should be acquainted with interdisciplinary approaches towards intellectual property, innovation, antitrust, privacy and technology policy research. They should also have an overview of current topics of international research in these areas.

Content
The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods applied to intellectual property, innovation, antitrust, privacy and technology policy issues. In particular, theoretical models, empirical and experimental research as well as legal research methods will be represented.

Lecture notes
Papers discussed in the workshop and lecture series are posted in advance on the course web page.
Communication

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Contract Design I (851-0742-00L; Fall 2023) is not a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2023)” and enroll. The password is “ContractDesign01”.

It is NOT a legal drafting class focused on contractual language.

The course follows a flipped-classroom model: You will watch learning videos specifically produced for this course ahead of class. The videos will be made available before the lecture each week and need to be watched ahead of coming to class. Computer-graded quizzes at the beginning of each class will test students’ understanding of the concepts introduced in the videos.

As the emphasis of this class is on class discussion, attendance is mandatory. Absent important reasons, you cannot miss class more than twice.

The lectures will be recorded but only made available to those who miss lectures with excused absence.

For ETH students: Your grade will consist of two parts:
1) You will take weekly computer-based quizzes during class time. Thus, it is important that you attend the lectures to be able to finish the quizzes and pass this course.
2) You compose short responses to take-home questions on case studies we assign and upload them ahead of course (Pass/Fail).

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH students also have to complete an additional group project.

Contract Design I is available to ETH students through the Science in Perspective (SIP) Program of D-GEss. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT.

If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gercke (lucas.gercke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).
<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Method-specific Competencies</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
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**851-0703-04L Law and Urban Space**  
Equivalent for students of D-ARCH.  

**Objective**  
Students recognize the interplay between legal structures and urban space. They can describe legal concepts with spatial impact. Moreover, they are able to compare legally binding targets with theoretical approaches in urban design. By analysing a specific place, students learn to find relevant norms, to analyse and to judge them with regard to urban design theories. Thereby, they are able to distinguish design and policy questions.

**Content**  
Using the terms «lawscape» (Philippopoulos-Mihalopoulos), we initially discuss general aspects of the interplay between legal rules and urban space. In the following weeks we consider the interplay with reference to different dimensions of urban space (e.g., morphological, social, functional dimension).

**Prerequisites / notice**  
Number of participants limited to: 40

**Literature**  
Editions officielles récentes des lois fédérales, en langue française (Code civil et Code des obligations) or Italienne (Codice civile e Codice delle obbligazioni), disponibles auprès de la plupart des librairies.

**851-0707-00L Space Planning Law and Environment**  
Equivalent for students of D-ARCH, D-BAUG, D-USYS.

**Objective**  
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

**Content**  

**Lecture notes**  
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

**Literature**  
Hänni, Peter, Planungs-, Bau- und besonderes Umweltschutzrecht, 7.A., Bern 2021

**851-0709-00L Introduction to Civil Law**  
Equivalent for students of D-ARCH, D-BAUG, D-USYS.

**Objective**  
Teaching of the principles of law, particularly private law. Introduction to law.

**Content**  
Editions officielles récentes des lois fédérales, en langue française (Code civil et Code des obligations) or Italienne (Codice civile e Codice delle obbligazioni), disponibles auprès de la plupart des librairies.

Sont indispensables:  
- le Code civil et le Code des obligations;  
- Sont conseillées:  
  - Nel, Urs Ch.: Le droit des obligations à l'usage des ingénieurs et des architectes, trad. Bovay, J., éd. Payot, Lausanne  
  - Boillod, J.-P.: Manuel de droit, éd Slatkin, Genève  
A comprehensive script will be made available online on the moodle platform.

**Analytical Competencies**

- Adaptability and Flexibility

**Subject-specific Competencies**

- Concepts and Theories

- Techniques and Technologies

- Analytical Competences

- Decision-making

- Media and Digital Technologies

- Problem-solving

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Self-awareness and Self-reflection

- Self-direction and Self-management

**Personal Competencies**

- Negotiation

- Adaptable and Flexible

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Method-specific Competencies**

- Negotiation

- Adaptable and Flexible

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Social Competencies**

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Self-awareness and Self-reflection

- Self-direction and Self-management

**Competencies**

- Concepts and Theories

- Techniques and Technologies

- Analytical Competences

- Decision-making

- Media and Digital Technologies

- Problem-solving

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Self-awareness and Self-reflection

- Self-direction and Self-management

**Lecture notes**

- Subject-specific Competencies

- Concepts and Theories

- Techniques and Technologies

- Analytical Competences

- Decision-making

- Media and Digital Technologies

- Problem-solving

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Self-awareness and Self-reflection

- Self-direction and Self-management

**Literature**

- Weitere Materialien, Links und Literatur sind auf dem Termin- und Themenplan aufgeführt (zu gegebener Zeit abrufbar via Moodle).

**Prerequisites / notice**

- Data: 02.07.2024 12:39

**Objective**

- The objective is knowing and understanding key legal concepts relevant for doing e-business, in particularly understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.

**Content**

Vorgesehene Strukturierung der Vorlesung:

1) Welches Recht gilt im E-Business?
   - Internationalität des Internets
   - Regulierte Branchen

2) Gestaltung und Vermarktung von E-Business-Angeboten
   - Verwendung fremder und Schutz der eigenen Inhalte
   - Haftung im E-Business (und wie sie beschränkt werden kann)
   - Domain-Namen

3) Beziehung zu E-Business-Kunden
   - Verträge im E-Business, Konsumentenschutz
   - Elektronische Signaturen
   - Datenschutz
   - Spam

4) Verträge mit E-Business-Providern

Änderungen, Umstellungen und Kürzungen bleiben vorbehalten. Der aktuelle Termin- und Themenplan ist zu gegebener Zeit über Moodle abrufbar.

Es wird mit Folien gearbeitet, die als PDF über Moodle vorgängig abrufbar sind. Auf dem Termin- und Themenplan (ebenfalls online abrufbar) sind Links zu Gesetzestexten und weiteren Unterlagen abrufbar. Schliesslich wird jede Vorlesung auch als Podcast aufgezeichnet, der jedoch nur für die Studierenden mit einem Passwort (erhältlich beim Dozenten) zugänglich sind.

Der Termin- und Themenplan ist zu gegebener Zeit über Moodle abrufbar.


**Prerequisites / notice**

- Particularly suitable for students of D-INFK, D-ITET.

**Abstract**

The course deals with the basic legal framework for doing e-business as well as using information technology. It discusses a variety of legal concepts and rules to be taken into account in practice, be it when designing and planning new media business models, be it when implementing online projects and undertaking information technology activities.

**Goal**

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

**Lecture notes**

Weitere Materialien, Links und Literatur sind auf dem Termin- und Themenplan aufgeführt (zu gegebener Zeit abrufbar via Moodle).

**Competencies**

- Concepts and Theories

- Techniques and Technologies

- Analytical Competences

- Decision-making

- Media and Digital Technologies

- Problem-solving

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Self-awareness and Self-reflection

- Self-direction and Self-management

**Personal Competencies**

- Negotiation

- Adaptable and Flexible

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Method-specific Competencies**

- Concepts and Theories

- Techniques and Technologies

- Analytical Competences

- Decision-making

- Media and Digital Technologies

- Problem-solving

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Social Competencies**

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Competencies**

- Concepts and Theories

- Techniques and Technologies

- Analytical Competences

- Decision-making

- Media and Digital Technologies

- Problem-solving

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Personal Competencies**

- Negotiation

- Adaptable and Flexible

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Method-specific Competencies**

- Concepts and Theories

- Techniques and Technologies

- Analytical Competences

- Decision-making

- Media and Digital Technologies

- Problem-solving

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Social Competencies**

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

**Competencies**

- Concepts and Theories

- Techniques and Technologies

- Analytical Competences

- Decision-making

- Media and Digital Technologies

- Problem-solving

- Communication

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

Abstract

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

Objective

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice

The lecture addresses students in the fields of engineering, science and other related technical fields.

Competencies

Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Problem-solving

Personal Competencies
- Critical Thinking
- Self-awareness and Self-reflection

Literature

- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005

Lecture notes

Abgegebene Unterlagen: Skript in digitaler Form

Content

Building a Robot Judge: Data Science for Decision-Making

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks. Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

Course objectives

- Students should be able to apply data science methods to legal decision-making.
- Students should be able to critically assess the potential biases and limitations of automated legal decision-making.
- Students should be able to design and implement machine learning models for legal prediction tasks.

Weeks

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture</th>
<th>Activity</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Data Science for Legal Prediction</td>
<td>Group Project: Model Selection</td>
</tr>
<tr>
<td>2</td>
<td>Regression Models for Legal Prediction</td>
<td>Individual Project: Model Evaluation</td>
</tr>
<tr>
<td>3</td>
<td>Classification Models for Legal Prediction</td>
<td>Group Project: Model Deployment</td>
</tr>
<tr>
<td>4</td>
<td>Deep Learning Models for Legal Prediction</td>
<td>Individual Project: Model Explanation</td>
</tr>
<tr>
<td>5</td>
<td>Algorithms for Fairness in Legal Prediction</td>
<td>Group Project: Model Auditing</td>
</tr>
<tr>
<td>6</td>
<td>Statistical and Empirical Methods for Legal Prediction</td>
<td>Individual Project: Model Implementation</td>
</tr>
<tr>
<td>7</td>
<td>Advanced Techniques for Legal Prediction</td>
<td>Group Project: Model Improvement</td>
</tr>
</tbody>
</table>

Prerequisites

- Basic knowledge of data science and machine learning
- Familiarity with Python and R

Student assessment

- Individual and group projects
- Semester paper

Admission

- Open to students with a background in computer science, statistics, or law
- Participation in the related seminar is not mandatory

Credit allocation

- 3 credits

Subject specific competencies

- Critical Thinking
- Self-awareness and Self-reflection

Method specific competencies

- Data Science for Legal Decision-Making
- Problem-solving

Personal competencies

- Problem-solving
- Self-awareness and Self-reflection

Literature

- E. Ash, Building a Robot Judge: Data Science for Decision-Making, 2024
- S. Stucki, R. Müller-Wyss, Grundbuchrecht für die Praxis, Zürich 2016
- Jörg Schmid / Bettina Hürlimann-Kaup, Sachenrecht, Zürich 2017
- Wolfgang Ernst / Samuel Zogg, Sachenrecht in a nutshell, Zürich 2020

Language

- English
Law & Tech

Abstract
This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective
The course is designed for a wide range of ETH students as well as for law students who are keen to deepen their understanding of cutting-edge technology. It offers an overview of key legal areas important for technology regulation, complemented by guest lectures on emerging technological trends.

In previous years, the course has featured esteemed speakers from various sectors, including industry leaders like Google, NGOs such as Digital Society Switzerland and The European Consumer Organization, regulatory bodies like the Swiss Competition Commission, and noted academics.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content
The planned course outline is below.
- Overview of Law and Technology
- Fundamental Rights
- AI & Discrimination
- Landmark Big Tech Cases
- Regulation of Digital Platforms & Content Moderation
- Online Consumer Protection
- Law and Tech Scholarship Series

A number of recent regulations will be discussed, including the EU’s AI Act, the Digital Services Act (DSA), and the Digital Markets Act (DMA), as well as emerging internet phenomena, like ChatGPT.

Prerequisites / notice
You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Law & Tech (851-0732-06L, HS 2024)" and enroll.

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Data and Society

Abstract
This lecture series explores the multifaceted role of data in shaping contemporary society, governance, and individual lives. The course equips students with a critical understanding of how data is made, managed, and preserved, and its implications for societal norms and individual rights.

Objective
At the end of the term, students will be able to:
- reflect concepts and theories that capture the performativity of data
- reflect concepts and theories that capture the socio-technical nature of data
- assess the implications of data practices for social and political ordering
- identify key actors, sites, and domain contexts of data practices

Competencies
Subject-specific Competencies
Themes and Theories

Method-specific Competencies
Analytical Competencies
Problem-solving

Social Competencies
Communication
Sensitivity to Diversity

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection

Supervised Research (Law, Economics, and Data Science)

Does not take place this semester.
Abstract

This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from econometrics and machine learning to questions in law, data science, and social science.

Objective

Students must have some data science and/or statistics experience. Some programming experience in Python, Stata, or R is required.

Prerequisites / notice

Apply tools from data science and social science to a new project, potentially in a group, to develop a paper or app. Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

851-0657-00L

Digital Technologies and Armed Conflict

W 2 credits 2G M. Vignati

Digital technologies are increasingly present in the context of armed conflicts, and they are primarily provided by private technology companies. This course presents current trends, analyzing the risks involved in the digitization of conflicts, both for civilians (as means and victims) and for private technology companies as the main actors of this transformation.

Objective

Students will learn how digital technologies are impacting modern conflicts and what are the actual and future trends in this domain. Students will focus on the implications for tech companies, understanding the new challenges from a technological, policy and legal perspective.

Content

1. Introduction: International Humanitarian Law IHL 101; International Committee of the Red Cross ICRC’s perspective; Terminology.
2. Digital Capabilities in Armed Conflict: Overview; Established cyber capabilities; The cyber weapons dilemma; Attribution and self-attribution; Other digital means during armed conflicts.
3. Connectivity in Crisis: No connectivity; Connectivity gap; Loss or limitation of connectivity; Stable connectivity; connected in crisis.
4. Hybrid and Unconventional Warfare: Kinetic and cyber offensive operation coordination; Disruption of digital services; The dual-use dilemma; The public-private partnership dilemma; Civilization of digital warfare. Total offense and whole-of-societies: a digital perspective of society’s active participation; The cognitive warfare: a digital perspective of modern low-intensity constant warfare.
5. The Potential Human Cost of Cyber Operations.
7. Case Studies (based on scenarios).

Sociology

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<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<tr>
<td>851-0252-10L</td>
<td>Project in Behavioural Finance</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>S. Andrzasewicz, C. Hölscher, A. C. Roberts</td>
</tr>
</tbody>
</table>

Abstract

In this seminar, students will study cognitive processes, behaviour and the underlying biological response to financial decisions. Research methods such as asset market experiments, lottery games, risk preference assessment, psychometrics, neuroimaging and psychophysiology of decision processes will be discussed. Financial bubbles and crashes will be the core interest.

Objective

This course has four main goals:
1) To learn about the most important topics within Behavioural Finance
2) To learn to effectively select, review and present information using modern telecommunication tools
3) To practice working on group projects in hybrid working conditions (online + in-person)
4) To solve an applied behavioral finance business case stemming from an industry partner

Content

The course does not contain mandatory reading. Instead, it offers suggested literature that provides guidance to the students who, prepare a presentation on core topics in behavioral finance. The point of this exercise is to critically select the most relevant information on a given topic and present to non-expert educated colleagues. At the same time, the audience learns about the key topics in behavioral finance. Every session involves a discussion moderated and supported by the lecturers.

Throughout the semester, students work on solutions to real business cases stemming from a company partner. They can receive feedback and guidance from project leaders of the industry partner and from the academic supervisors. In the final meeting of the semester, students pitch solutions to their business cases.

The course takes place entirely online. The objective is to prepare the students for the future work in online and hybrid arrangements.

Prerequisites / notice

Students from all domains of ETH and all levels of education are welcome in the course.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation

Personal Competencies

- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Network Modeling

W 3 credits 2G C. Stadtfeld, I. Smokovic, A. Uzaheta Berdugo

Abstract

Social Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks, including statistical and mathematical methods. In this course, the emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.
Objective

The following topics will be covered:

- Introduction to network models and their applications

- Stylized models:
  * uniform random graph models
  * small world models
  * preferential attachment models

- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)

- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Content

The following topics will be covered:

- Introduction to network models and their applications

- Stylized models:
  * uniform random graph models
  * small world models
  * preferential attachment models

- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)

- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)
  * Models for relational event data: dynamic network actor models (DyNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Lecture notes

Slides and lecture notes are distributed via the associated course moodle.

Literature


Prerequisites / notice

Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

<table>
<thead>
<tr>
<th>851-0252-15L</th>
<th>Network Analysis</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>U. Brandes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection. Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency. The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>* Empirical Research and Network Data * Macro and Micro Structure * Centrality * Roles * Cohesion * Influence</td>
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</tbody>
</table>

Lecture notes

Slides and lecture notes are distributed via the associated course moodle.

Literature

Abstract
The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g., sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work.

Objective
Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

Computational Social Science and Global Systems Science serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e. an interdisciplinary integration of knowledge.

Literature
Ball: Why Society Is A Complex Matter
• Helbing: Social Self-Organization
• Helbing: Managing Complexity
• Colander/Kupers: Complexity and the Art of Public Policy
• Mitchell: Complexity
• Buckley: Society – A Complex Adaptive System
• Castellani/Hafferty: Sociology and Complexity Science
• Mikhailov/Calenbuhr: From Cells to Society
• Mainzer: Thinking in Complexity
• Sawyer: Social Emergence
• Books published by the Santa Fe Institute

Computational Social Science
https://science.sciencemag.org/content/sci/323/5915/721.full.pdf

Manifesto of Computational Social Science
https://link.springer.com/article/10.1140/epjst/e2012-01697-8

Social Self-Organisation

How simple rules determine pedestrian behaviour and crowd disasters
https://www.pnas.org/content/108/17/6884.short

Peer review and competition in the Art Exhibition Game
https://www.pnas.org/content/113/30/8414.short

Generalized network dismantling
https://www.pnas.org/content/116/14/6554.short

Computational Social Science: Obstacles and Opportunities
https://science.sciencemag.org/content/369/6507/1060?rss%3D1=

Bit by Bit: Social Research in the Digital Age
https://www.amazon.co.uk/Bit-Social-Research-Digital-Age-ebook/dp/B072MPFX2/

Further literature will be recommended in the lectures.

Prerequisites / notice
Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
851-0586-03L  
**Applied Network Science: Sports Networks**  
W 3 credits 2S U. Brandes

**Abstract**
We study applications of network science methods, this semester in the domain of sports. Topics are selected for diversity in sports, research questions, and techniques with applications such as passing networks, team rankings, or career trajectories. Student teams present results from the recent literature, possibly with replication, in a conference format.

**Objective**
Network science as a paradigm is entering domains from engineering to the humanities but application is tricky. By examples from recent research on sports analytics, students learn to appreciate that, and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.

851-0745-00L  
**Ethics Workshop: The Impact of Digital Life on Society**  
Open to all Master level / PhD students.

Abstract  
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Objective  
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.

Content  
The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2598 of 2667
Advanced Topics in Evidence-Based Design for Architecture

**Course requirements:** Completion of the course Evidence-Based Design: Methods and Tools For Evaluating Architectural Design (851-0252-08L).

**Abstract**
Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layouts from the perspective of end-users.

**Objective**
Students will build on their previous projects as part of the course "Evidence-Based Design: Methods and Tools For Evaluating Architectural Design" (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University Designing the post-pandemic hospital with evidence. for people. The course is funded by an ETH innoedum project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

Complex Social Systems: Modeling Agents, Learning, and Games

**Prerequisites:** Basic programming skills, elementary probability and statistics.

**Abstract**
This course introduces mathematical and computational models to study techno-socioeconomic systems and the process of scientific research. Students develop a significant project to tackle techno-economic challenges in application domains of complex systems. They are expected to implement a model and to communicate their results through a project report and a short oral presentation.

**Objective**
See your own field of study in a wider context ("Science in Perspective"), e.g. see the psychological, social, economic, environmental, historical, ethical, or philosophical connections and implications. Learn to think critically and out of the box. Question what you believe you know for sure. Get to know surprising, counterintuitive properties of complex (non-linearly interacting, networked, multi-component) systems. Learn about collaboration.

**Content**
By the end of the course, the students should be able to better understand the literature on complex social systems, develop their own models for studying specific phenomena and report results according to the standards of the relevant scientific literature by presenting their results both numerically and graphically.

At the end of the course, the students will deliver a report, computer code and a short oral presentation. To collect credit points, students will have to actively contribute and give a circa 30 minutes presentation in the course on a subject agreed with the lecturers, after which the presentation will be discussed. The presentation will be graded.

Students are expected to implement themselves models of techno-socio-economic processes and systems, particularly agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature, its presentation, and documentation by a project report.

**Lecture notes**
The lecture slides will be presented on the course Moodle after each lecture.

**Literature**
Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
https://journals.aps.org/revmodphys/vol.73/issue.1

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

**Prerequisites / notice**
The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies fostered
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation fostered
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed
- Negotiation fostered

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution.

Objective
To collect credit points, students must actively contribute and give an individual, circa 20-minute presentation in the seminar on a subject agreed upon with the lecturer. After the presentation, it will be discussed and graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.

Literature
Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)

Michael Batty, Kay Axhausen et al.
Smart cities of the future

Books by Michael Batty:
- How social influence can undermine the wisdom of crowd effect
- Evidence for a collective intelligence factor in the performance of human groups
- Optimal incentives for collective intelligence
- Collective Intelligence: Creating a Prosperous World at Peace
- Big Mind: How Collective Intelligence Can Change Our World
- Programming Collective Intelligence
- Urban architecture as connective-collective intelligence. Which spaces of interaction?
- Build digital democracy
- How to make democracy work in the digital age
- Digital Democracy: How to make it work?
- Proof of witness presence: Blockchain consensus for augmented democracy in smart cities
- Iterative Learning Control for Multi-agent Systems Coordination

Decentralized Collective Learning for Self-managed Sharing Economies

Prerequisites / notice
Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
851-0252-07L  Humans and Social Networks in the Digital Age  W  3 credits  2S  C. Stadtfeld, Z. Kovacevic, X. Xu

Abstract
The digital transformation profoundly impacts humans and how they behave online and offline. Interactions in online social networks offer new opportunities (e.g., political movements, global cultural diffusion) and risks (e.g., fake news). In this seminar, we examine recent sociological and psychological research on how the digital transformation affects individuals and their social behaviors.

Objective
By the end of this seminar, students will be able to identify and compare different approaches in (online) social network research. They will be familiar with recent publications in the fields of social networks and computational social science and be able to critically participate in a number of open debates in these fields. Among others, these debates are centered around the types and measurement of social behavior in online and offline settings, ethical challenges in conducting social networks research, the effects of the digital transformation on people's feelings, thoughts, preferences, and behaviors (e.g., digital mental health), and how online social and cultural phenomena emerge (e.g., the diffusion of culture and the spread of social movements).

Content
The digital transformation has made the “online world” increasingly important for the “offline world”. Hence, interactions in online social networks ultimately affect how people feel, think, behave and interact in offline settings. This course aims to present and structure open debates in online and offline social network research with a focus on social network processes, individual outcomes, and emergent phenomena. By taking a social networks perspective, we view individuals and their behavior in online and offline settings as part of a larger social environment and social phenomena as emerging from interrelated social behavior.

851-0685-00L  Data and Society  W  3 credits  2V  M. Leese

Abstract
This lecture series explores the multifaceted role of data in shaping contemporary society, governance, and individual lives. The course equips students with a critical understanding of how data is made, managed, and preserved, and its implications for societal norms and individual rights.

Objective
At the end of the term, students will be able to:
• reflect concepts and theories that capture the performativity of data
• reflect concepts and theories that capture the socio-technical nature of data
• assess the implications of data practices for social and political ordering
• identify key actors, sites, and domain contexts of data practices

Competencies
Subject-specific Competencies
Concepts and Theories  assessed
Techniques and Technologies  assessed
Method-specific Competencies
Analytical Competencies  assessed
Problem-solving  fostered
Social Competencies
Communication  fostered
Sensitivity to Diversity  fostered
Personal Competencies
Adaptability and Flexibility  fostered
Creative Thinking  assessed
Critical Thinking  assessed
Integrity and Work Ethics  assessed
Self-awareness and Self-reflection  assessed
Self-direction and Self-management  assessed

851-0454-00L  AI Personhood, Social Justice, and Cross-Cultural Dialogues in the Digital Age  W  3 credits  2S  K. Wodajo

Abstract
The course fosters critical, culturally conscious reflection on AI development and regulation by 1) exploring cross-cultural assessment of the concept of personhood and collective in digital society and how these concepts are reflected in AI development and governance. 2) inspiring reflection on social justice issues stemming from major (mis)conceptions of personhood in AI development and governance

Objective
• Understand and differentiate various concepts of personhood and collective in digital societies
• Critically evaluate emerging regulations in the field of AI
• Examine the implications of these regulatory frameworks and their conception of personhood for the AI human future
• Develop creative & culturally conscious analytical skill on issues of social justice in
On 13 March 2024, the European Parliament voted in favour of the long-awaited EU AI Act. On October 30, 2023, the US passed an Executive Order on the safe, secure, and trustworthy development and use of AI. Meanwhile, China has been adopting regulations: the 2021 regulation on recommendation algorithms, 2022 rules for deep synthesis (synthetically generated content), and draft rules on generative AI on August 15, 2023. In the face of this race to develop and regulate AI across various legal, regulatory, and cultural settings, this course exposes students to the overarching question: How can we envision an AI-human future that accommodates a pluriverse and ensures a just future?

In everyday life, from education, policy deliberation, planning and prediction, governance of the human behavior and the beyond human, to social and private life center, and entertainments, AI systems and AI-enabled products play a significant role. At the very center of this sociotechnical system is the human, often referred to as the ‘data subject’. This raises foundational questions: Who or what is this ‘data subject’? What warrants its protection or what makes it worthy of protection – is it the human dignity, autonomy, rationality, legally protected rights or something beyond and within all these? Who/what is considered a protected ‘data subject’, and who/what is not? While these questions might seem new, they revisit old ethical dilemmas.

However, there is no one-fits-all answer to these questions. Responses vary greatly depending on local and cultural contexts across different jurisdictions and societies. The way AI development and regulatory practices conceptualize the subject of protection – that is, the human and its environ diverges, leading to varied interpretations of personhood and what warrants protection. What personhood means and what is protected and not are not only matters of policy or legislative interpretations and standardization but a matter of social justice.

With this consideration, the course invites and encourages students to explore the concept of personhood from a cross-cultural perspective, incorporating epistemologies from the ‘South’, including Afro-communitarianism, pluriverse theories, and Confucianism. Students are then guided to critically examine personhood and community within the context of competing AI regulatory frameworks, such as those in the EU, China, Brazil, and the US, as well as in their own interactions with AI systems. By identifying conceptual limitations in current understandings of personhood and the centrality of the collective within contemporary AI regulation and practice, students can address core social justice issues. These include the overemphasizes on individualism, which overlooks the communal and relational aspects of existence (including the human and the beyond human), the instrumentalization of the environment, and exploitative business models.

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<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<th>Content</th>
<th>851-0455-00L 701-0786-00L</th>
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<tbody>
<tr>
<td>Science, Trust and Politics</td>
<td>W 3 credits 2S G. Dorthoe</td>
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</table>

Abstract

The seminar aims to inspire a nuanced understanding of the dynamics of expertise in society. Cross-fertilizing literature from science and technology studies (STS) and from activists’ movements, it focuses on contemporary controversies around emerging technologies and climate policy, where trust in science is said to be undermined (e.g., climate skepticism or anti-vaccine movements).

Objective

1) Introduce to the role and functions of expertise in democratic societies. 2) Familiarize with assumptions about science and society embedded in contemporary controversies. 3) Inspire critical perspectives on (dis)trust in science through activists’ movements on contested environmental and technological issues. 4) Develop a creative position on the relations between science, trust and politics.

Content

Engineers and scientists often pursue their studies and research in the hope that their knowledge can contribute to a better world, inform democratic deliberation and help public understanding of complex issues. Yet this special status of science and technology is being increasingly contested by marginalized publics, lobbies, exposed populations, and by members of the scientific communities themselves. Climate skepticism or vaccine hesitancy are some of the most vivid examples of this confusing situation. In this seminar, students will learn to reflect on expertise as a form of scientific engagement in the messiness of democratic deliberation and public life, beyond the noble but outdated ideal of “speaking truth to power”. The exercise of expertise is stumbling upon several conundrums. Which knowledge is relevant in which situation? How to make sure that some crucial perspectives are not left in the shadows? How to identify representative experts and make sure that they speak on behalf of a structured community? Whose voices are being silenced? On the other side of the spectrum, the public is often said to lack proper understanding of science and thus in need of being educated or disciplined. Or it is suspected of being manipulated by lobbies or foreign hostile powers, or of being too attached to its own privileges and unwilling to act in favor of the common good. Whose agency is being acknowledged in sociotechnical controversies and whose agency is being denied and why? The seminar will provide a deep understanding of these perspectives, by putting them in a broader historical and epistemological context. Students will thus learn to critically assess their strengths as well as their blind spots.

Whereas opposing technological developments (anti 5G or anti-vaccine activists) or pushing to act accordingly to science (pro climate movements such as Extinction Rebellion or Scientist Rebellion), activists’ movements make up for a rich field of investigation on the dynamics of expertise and of how various publics can make sense of scientific knowledge. Cross-fertilizing activist’s texts and experiences with literature in science and technology studies and anthropology, this class will be organized as a structured conversation and a collective mapping of actors and key concepts of sociotechnical controversies. Over the course of the semester, students will learn not only to navigate some of the most heated contemporary debates, but also to articulate their own position on an issue of their choice.

Competencies

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Communication
- Negotiation
- Adaptability and Flexibility
- Critical Thinking
- Self-awareness and Self-reflection

Method-specific Competencies

- Techniques and Technologies
- Decision-making
- Cooperation and Teamwork
- Sensitivity to Diversity

Social Competencies

- Media and Digital Technologies
- Problem-solving
- Leadership and Responsibility
- Self-presentation and Social Influence
- Creativity and Work Ethics

Personal Competencies

- Fostered
- Assessed
- Fostered
- Assessed
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- Fostered
- Fostered
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- Fostered
- Assessed

Self-awareness and Self-reflection
Abstract

This course is intended to demonstrate how environmental decisions can be optimized and conflicts better dealt with by using mediation. Case studies will focus on construction of windmills for electricity purposes, landfills, sustainable city-planning or Human-Wildlife Conflict and Coexistence.

Objective

- Develop comprehension of legal and social responses to environmental conflicts
- Recognize the most important participative techniques and their ranges
- Develop concepts for doing and evaluating mediation processes
- Estimate the potential and limitations of cooperative environmental planning
- Train communicative skills (presentation, moderation, discussion design, negotiation), especially by participating at a mediation

Content

To this end, we will look at the most important techniques of mediation and put them into the context of today's legislation, participation and conflict culture. The potential and limitations of the individual techniques will be discussed using current Swiss and international case studies, namely in the field of wind energy as well as of landfills and Human-Wildlife Conflict and Coexistence (wolves, bears, elephants). Students can do conflict analyses, for instance, as part of individual and group analyses and a half-day mediation-simulation, develop technique concepts and train their own communicative and negotiation skills.

Lecture notes

A reader will be handed out.

Competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Concepts and Theories</td>
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<td>Creative Thinking</td>
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<tr>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
<td>Cooperation and Teamwork</td>
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<td>Problem-solving</td>
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Science Research

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<tr>
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<th>Type</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>851-0020-00L</td>
<td>Gender and Science</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>E. Valdameri</td>
</tr>
</tbody>
</table>

Abstract

This lecture series offers an introduction to the relationship between gender and science, with a focus on the specific intersections with the sciences taught at ETH.

Objective

This lecture series is designed to acquaint students from all levels and departments with the various ways in which gender perspectives matter for specific scientific disciplines, as well as for science in general. Students will learn to recognize and analyse the specific ways in which scientific theories and methods are gendered. They will be able to discuss and reflect how these topics are connected to their own scientific disciplines.

Content

There is agreement across academic disciplines today that gender influences and structures the production of knowledge and that scientific knowledge production in turn shapes gender notions. Even within "hard" sciences such as mathematics, physics, engineering, etc., gender is a significant factor in determining what counts as "objective" knowledge, who can know it, what kind of knowledge is produced, or how this knowledge is acquired and justified. Feminist research aims to reveal how dominant conceptions of science and knowledge practices disadvantage women*, and other subordinate groups, with the goal of reforming these practices. An important part of feminist critique is to show that such efforts substantially improve the overall quality of research. The semester will start with two introductory lectures acquainting students with research questions in the field of Gender and Science by summarizing its key concepts and methods. It will then continue as a series of weekly guest lectures by scholars from different scientific disciplines that provide accessible insights into the intersection between gender studies and the guest lecturer's research field. Students will thereby be encouraged to learn from concrete examples rather than abstract theory. The goal is for students to understand how to apply concepts and methods of gender studies to their particular disciplines. Intermediate discussions with the students will provide a forum for critically reflecting the content of the lectures and the connections to their own academic fields and practices.

All lectures by the guest speakers will also be open to the broader ETH public, while the introductory and discussion sessions are only for registered course participants.

Type B: Reflection About Subject-Specific Methods and Contents

Subject-specific courses. Particularly relevant for students interested in those subjects.

All these courses are also listed under the category “Typ A”, and every student can enroll in these courses.

D-ARCH

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>851-0703-00L</td>
<td>Introduction to Law</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>O. Streiff Gnopff</td>
</tr>
</tbody>
</table>

Abstract

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered. The focus is on legal problems related to space. Active participation is expected in short interactive sequences.

Objective

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law. They are able to apply the fundamentals in more advanced law classes and to recognize the relevance of law in their own field.

Content

Basic concepts of law, sources of law.

Private law: Contract law (particularly contract for work and services), tort law, property law.

Public law: Human rights, administrative law, procurement law, procedural law.

Insights into the law of the EU.

Lecture notes

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Literature

Further documents will be available online (https://moodle-app2.let.ethz.ch/course/view.php?id=22904).

Competencies

<table>
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Contract Design I

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or L2H credentials. Then search for “Contract Design I (851-0742-00L; Fall 2023)” and enroll. The
Law and Urban Space

Abstract

Legal rules are tied to urban space. Illustrative is the relation between land ownership and urban morphology. Legal concepts with spatial impacts are introduced and related to the theory of urban design. Moreover, it is discussed how these concepts shape specific places. The course includes interactive sequences for which active participation is expected.

Objective

Students recognize the interplay between legal structures and urban space. They can describe legal concepts with spatial impact. Moreover, they are able to compare legally binding targets with theoretical approaches in urban design. By analysing a specific place, students learn to find relevant norms, to analyse and to judge them with regard to urban design theories. Thereby, they are able to distinguish design and policy questions.

Content

Using the term «lawscape» (Philippopoulos-Mihalopoulos), we initially discuss general aspects of the interplay between legal rules and urban space. In the following weeks we consider the interplay with reference to different dimensions of urban space (e.g. morphological, social, functional dimension).

Working tools are theoretical texts, legal rules, court decisions as well as site analyses. Students prepare the texts for joint discussions and undertake a case study in small groups. Selected case studies are presented and discussed in a final meeting.

Lecture notes

See Literature.

Literature

Documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=20128).

Number of participants limited to: 40

Competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Negotiation assessed

Personal Competencies

Creative Thinking assessed

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH and UNISG students should check out the description of the class at their respective home institutions.

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Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based assessed

### Subject-specific Competencies

- **Real estate property law** (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: C. Hölscher
- **Space Planning Law and Environment** (esp. constitutional and statutory provisions). Practical training: O. Bucher

### Analytical Competencies

- **Concepts and Theories**
- **Method-specific Competencies**
- **Social Competencies**
- **Personal Competencies**

### Presentations

- **Human-computer interaction** and selected topics:
  - History of HCI
  - Research ethics
  - Literature reviews
  - Participant-free methods: cognitive walkthrough and heuristic evaluation
  - Card sorting and information architecture
  - Usability studies
  - Unmoderated research and diary studies
  - Surveys
  - User Logs and metric frameworks

The final project demonstrates class topic adoption by deeply exploring one HCI problem using the covered methods and tools. Students will choose a research topic and execute their research plan. They will individually write a formal report including problem definition, literature review, methodology, findings, and discussion.

### Critical Thinking

- **Problem-solving**
- **Decision-making**
- **Techniques and Technologies**
- **Analytical Competencies**
- **Decision-making**
- **Problem-solving**
- **Creative Thinking**
- **Critical Thinking**

### Evidence-Based Design: Methods and Tools for Evaluating Architectural Design

- **Content**
  - The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based assessed

### Personal Competencies

- **Critical Thinking**

On a weekly basis, students will conduct authentic research in class covering the topics above. They will submit their in-class research results regularly and also present their findings to the class once per semester.

### Real Estate Property Law

- **Objective**
  - The legal principles of real estate property law can be correctly interpreted and applied in daily life.

### Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.
From Traffic Modeling to Smart Cities and Digital Democracies

Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.

Objective
To collect credit points, students must actively contribute and give an individual, circa 20-minute presentation in the seminar on a subject agreed upon with the lecturer. After the presentation, it will be discussed and graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.

Literature
- Dirk Helbing
  Analytical Theory of Traffic Flow (collection of papers)
- Michael Batty, Kay Axhausen et al.
  Smart cities of the future
- Books by Michael Batty:
  How social influence can undermine the wisdom of crowd effect
  Evidence for a collective intelligence factor in the performance of human groups
  Optimal incentives for collective intelligence
  Collective Intelligence: Creating a Prosperous World at Peace
  Big Mind: How Collective Intelligence Can Change Our World
  Programming Collective Intelligence
  Urban architecture as connective-collective intelligence. Which spaces of interaction?
  Build digital democracy
  How to make democracy work in the digital age
  Digital Democracy: How to make it work?
  Proof of witness presence: Blockchain consensus for augmented democracy in smart cities
  Iterative Learning Control for Multi-agent Systems Coordination
  Decentralized Collective Learning for Self-managed Sharing Economies
- Prerequisites / notice
  Students need to present a new subject, for which they have not earned any credit points before.
  Good scientific practices, in particular citation and quotation rules, must be properly complied with.
  Chatham House rules apply to this course. Materials may not be shared without previous written permission.
Adaptability and Flexibility fostered

Assessed

Concepts and Theories assessed
Techniques and Technologies assessed

Adaptive and Flexible

Assessed

Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed
Project Management fostered

Social Competencies

Communication assessed
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies

Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

851-0253-08L
Advanced Topics in Evidence-Based Design for Architecture

Course requirements: Completion of the course Evidence-Based Design: Methods and Tools For Evaluating Architectural Design (851-0252-08L).

Abstract
Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layouts from the perspective of end-users.

Objective
Students will build on their previous projects as part of the course "Evidence-Based Design: Methods and Tools For Evaluating Architectural Design" (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University. Designing the post-pandemic hospital with evidence for people. The course is funded by an ETH innovedum project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

851-0453-00L
Artificial Intelligence and Human Values

Abstract
This course introduces students to the ethical, political and legal debates and transformations in relation to Artificial Intelligence and provides students with concepts and methods from the constructivist and interpretive social sciences to work towards responsible and democratic human-technology futures.

Objective
The main objectives of the course are to enable students to 1) identify the ways in which human values and developments of AI technologies are entangled, 2) articulate what is significant about contemporary transformations in AI and society, and 3) participate and shape the relationship between human values and AI as citizens and professionals.

Content
The growing presence of AI tools for public use, for public administration, inside corporations and in scientific research raises many questions about the ethical, political, legal consequences of these technologies. This course is built around multiple sites of encounter among human values and AI, including bodies, persons, cities, labs, law, and environment. In each site, we inquire about what and whose values are being prioritized and with what consequences. The course also investigates existing best-practices around how to "align" human values with AI (e.g., human-centric design, alignment, reproducibility, transparency, explainability) and introduces students to regimes of ethics and governance of AI being proposed in jurisdictions around the world. Students learn to unpack the values and assumptions in existing techniques and frameworks for the design and governance of AI and to engage constructively with diverse stakeholders to shape the human-technology future towards aims that are reflexive, responsible, and democratic.

851-0037-00L
Ethics of Building

Abstract
Building practices have often been associated with utopian visions and promises of a more just way of living together. But to what extent can the built environment contribute to a better society? What role can mathematical models or data analyses play in questions of distributive justice in the city? Is it ever possible to build sustainably, or is building always also destroying the environment?

Objective
Students will learn about contemporary debates in architectural and urban planning ethics. We will discuss the positions against the background of their historical predecessors and current contexts. Students will work on small case studies in which they will ethically analyze the construction of a building, a district, or a city. The seminar includes a student-co-led expedition through Zurich.

Content
Throughout history, there have always been utopian visions and promises tied to construction, be it of individual objects, such as towers, or of entire cities. For example, thanks to their geometric shapes, modern cities are supposed to enable more equality among people, even the equal distribution of sunshine, as Le Corbusier once dreamed. But to what extent is it even possible to create more equality by designing living spaces? A wall automatically excludes by protecting the interior. Building cities always means defining the far and the near, the center and the periphery, the upper and the lower. These orientations translate into social relations for example of those who have to commute far and those who are at the center of the action. Who determines how and what is built and whose perspective is not taken into account? To whom does a built landscape afford agency and to whom not? Mathematical models can predict the probabilities of encounters in space, which also can have an impact on social relationships. What is the relevance of such models as well as the more recent data analyses in questions of distributive justice? Is it possible to distribute social participation in the city? Does construction always have to destroy and replace the underlying nature? How do our building practices affect coexistence with other species?

We will not be able to solve these problems in one semester, but we will intensively grapple with the overarching question implied in all of them. The question is on the extent to which the built environment takes on ethical significance for human (and other) forms of life, and how are we to understand ethics in general if it is to respond to such questions.
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.
Contract Design I

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Contract Design I (851-0742-00L; Fall 2023)" and enroll. The password is "ContractDesign01".

It is NOT a legal drafting class focused on contractual language.

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

Abstract

Contract Design I is taught by Professor Stremitzer and aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place and then engineer contracts that achieve the desired outcome.

Objective

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Contract Design will provide you with analytical tools to design contracts that help you be better lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie financing, production & distribution, construction & development, M&A deals, venture capital financing, to executive compensation and many other types of transactions.

The course follows a flipped-classroom model: You will watch learning videos specifically produced for this course ahead of class. We will use class time to discuss real-world case studies. The videos will be made available before the lecture each week and need to be watched ahead of coming to class. Computer-graded quizzes at the beginning of each class will test students’ understanding of the concepts introduced in the videos.

As the emphasis of this class is on class discussion, attendance is mandatory. Absent important reasons, you cannot miss class more than twice.

The lectures will be recorded but only made available to those who miss lectures with excused absence.

For ETH students: Your grade will consist of two parts:
1) You will take weekly computer-based quizzes during class time. Thus, it is important that you attend the lectures to be able to finish the quizzes and pass this course.
2) You compose short responses to take-home questions on case studies we assign and upload them ahead of class (Pass/Fail).

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH students also have to complete an additional group project.

UZH and UNISG students should check out the description of the class at their respective home institutions.

Lecture notes

Handouts, prerecorded videos, slides, case studies, and other materials available on a dedicated webpage: contractdesign.org. Access to this webpage is free of charge for ETH students as ETH purchased a license for ETH students.

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UZH and UNISG students should check out the description of the class at their respective home institutions.

Prerequisites / notice

Attendance is mandatory. You are only allowed to miss two lectures unless there are special circumstances.

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT.

If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Competencies

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<td>Self-awareness and Self-reflection</td>
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Space Planning Law and Environment

Particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT.

Abstract

System of swiss planning law, Constitutional and statutory provisions, Space planning and fundamental rights, Instruments, Application, legal protection, enforcement, Practical training.

Objective

Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.
Content

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999
Hänni, Peter, Planungs-, Bau- und besonderes Umweltschutzrecht, 7.A., Bern 2021

Competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving
Social Competencies
Communication
Personal Competencies
Creative Thinking
Critical Thinking

701-0703-00L Environmental Ethics (University of Zurich) W 3 credits 2V University lecturers

Abstract
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

052-0801-00L Global History of Urban Design I W 2 credits 2G T. Avermaete

Abstract
This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

Objective
The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students’ future design work.

Content
In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

01. The History and Theory of the City as Project
02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
03. The Idea of the Polis: Rome, Greece and Beyond
04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
05. Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization
07: The City of Labor: Company Towns as Cross-Cultural Phenomenon
08: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
09: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
10: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

Lecture notes
Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

Literature
There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

Prerequisites / notice
Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).
Abgegebene Unterlagen: Skript in digitaler Form

3 credits

- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Die Umweltbestimmung, in ZBGR 2013, 238 ff.
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005

Literature

Abgegebene Unterlagen: Skript in digitaler Form

851-0724-01L Real Estate Property Law

 Particularly suitable for students of D-ARCH, D-BAUG, D-USYS.

- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

851-0763-00L Supervised Research (Law, Economics, and Data Science)

 Does not take place this semester.

- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Die Umweltbestimmung, in ZBGR 2013, 238 ff.

851-0549-00L WebClass Introductory Course History of Technology

 Particularly suitable for students D-BAUG, D-INFK, D-ITET, D-MATL, D-MAVT.

- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of K. Houshang Pour Islam.

### Analytical Competencies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>851-0738-01L</td>
<td>The Role of Intellectual Property in the Engineering and Technical Sector</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>K. Houshang Pour Islam</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

**Objective**
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

**Case studies** will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

### Subject-specific Competencies

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<td>851-0732-06L</td>
<td>Law &amp; Tech</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>A. Stremitzer, J. Merane</td>
</tr>
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</table>

**Abstract**
The course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

The course is designed for a wide range of ETH students as well as for law students who are keen to deepen their understanding of cutting-edge technology. It offers an overview of key legal areas important for technology regulation, complemented by guest lectures on emerging technological trends.

In previous years, the course has featured esteemed speakers from various sectors, including industry leaders like Google, NGOs such as Digital Society Switzerland and The European Consumer Organization, regulatory bodies like the Swiss Competition Commission, and noted academics.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

**Content**
The planned course outline is below.

- Overview of Law and Technology
- Fundamental Rights
- AI & Discrimination
- Landmark Big Tech Cases
- Regulation of Digital Platforms & Content Moderation
- Online Consumer Protection
- Law and Tech Scholarship Series

A number of recent regulations will be discussed, including the EU's AI Act, the Digital Services Act (DSA), and the Digital Markets Act (DMA), as well as emerging internet phenomena, like ChatGPT.

**Prerequisites / notice**
You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Law & Tech (851-0732-06L, HS 2024)” and enroll.

### Social Competencies

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturer</th>
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<tr>
<td>376-1661-00L</td>
<td>Ethics of Life Sciences and Biotechnology</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Blasimme, E. Vayena</td>
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**Abstract**

### Competencies

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</table>

**Subject-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Media and Digital Technologies
- Communication
- Creative Thinking
- Critical Thinking

**Method-specific Competencies**

- Problem-solving
- Critical Thinking
- Self-awareness and Self-reflection

**Personal Competencies**

- Concepts and Theories
- Analytical Competencies
- Media and Digital Technologies
- Communication
- Critical Thinking
Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

Competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
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<td>Techniques and Technologies</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<tr>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<td>fostered</td>
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</table>

851-0763-00L Supervised Research (Law, Economics, and Data Science) W 3 credits E. Ash
Does not take place this semester.

Abstract
This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from econometrics and machine learning to questions in law, data science, and social science.

Objective
Students must have some data science and/or statistics experience. Some programming experience in Python, Stata, or R is required. Apply tools from data science and social science to a new project, potentially in a group, to develop a paper or app.

Prerequisites / notice
Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

851-0157-28L Life and Death W 3 credits 2V M. Hagner
Particularly suitable for students of D-BIOL, D-HEST, D-CHAB, D-USYS

Abstract
This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Objective
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0272-00L The Cutting Edge of Social Brain Imaging W 2 credits 2S E. Cross, R. Moffat

Abstract
This seminar introduces the fundamentals and latest research developments of brain imaging in real-world contexts. We explore topics from imaging multiple people’s brains simultaneously as they interact to neuro-ethics and neuro-art, while maintaining a strong focus on critical evaluation of research practices and applications of brain imaging of and during social interaction.

Objective
- To familiarize students with current concepts, theories, methods, and findings from social brain-imaging sciences
- To develop a critical view of extant findings and the tools for evaluating the quality of evidence and data, as well as ethical implications
Content

Rapid advances in the technologies and empirical approaches used in imaging the human brain have opened exciting windows into how the human brain coordinates social interaction. These advances include imaging the brain’s function during real social interactions, training behaviors with feedback based on real-time brain activity, and even generating art directly from brain signals. With them, these advances have brought novel ethical implications regarding their implementation in research and potentially, their use by the public, for both therapeutic and possible "neurohacking" applications. In this seminar, students will be introduced to various neuroimaging approaches for social neuroscience generally, as well as to approaches for measuring social brain function in real life, and will gain insights into related ethical considerations.

The seminar builds on the active participation of students in reading, presenting, and critically discussing selected papers in the field. In a final small-group assignment, students are required to integrate and elaborate upon topics covered in the seminar by presenting and debating a novel research proposal for addressing a timely research question related to the use of brain imaging in the context of social interactions. No prior experience or knowledge in brain imaging is required.

Competencies

Subject-specific Competencies
- Concepts and Theories: fostered
- Techniques and Technologies: fostered

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: assessed
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: assessed

851-0271-00L Neuroaesthetics - Exploring the Science of Aesthetic Experience
W 2 credits 2S E. Cross, I. Bara

Abstract
This seminar introduces students to theory and research, challenges, and opportunities in neuroaesthetics, with a clear emphasis on the interdisciplinary nature of the discipline situated at the intersection of neuroscience, psychology, and art appreciation. Foundational empirical methods and critical perspectives of research approaches in neuroaesthetics are considered.

Objective
- to familiarize students with concepts, models, methods, brain and behavioral findings related to aesthetic experience.
- to develop a critical understanding in evaluating the theoretical and empirical findings in neuroaesthetics
- to integrate the acquired knowledge to critically debate and discuss the conceptual and empirical issues related to the science of aesthetic experience

Content
In this seminar, students will learn about the foundational principles of neuroaesthetics, which explores the cognitive and brain processes involved in aesthetic experience. A key focus will be placed on developing an appreciation of the interdisciplinary methods used in the neuroaesthetics field – ranging from neuroscience, psychology, philosophy, and art history. The seminar is based on the active engagement of students in reading, presenting, and critically discussing selected papers in the field. In a final small-group assignment, students are expected to incorporate and elaborate upon the content covered in the seminar by presenting and discussing a novel research proposal for tackling a timely research question related to aesthetic experience.

Method-specific Competencies
- Analytical Competencies: fostered
- Decision-making: fostered
- Media and Digital Technologies: fostered
- Problem-solving: fostered
- Project Management: fostered

Social Competencies
- Communication: fostered
- Cooperation and Teamwork: fostered
- Customer Orientation: fostered
- Leadership and Responsibility: fostered
- Self-presentation and Social Influence: fostered
- Sensitivity to Diversity: fostered

Personal Competencies
- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: fostered
- Self-direction and Self-management: fostered

D-BSSE

851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector
W 2 credits 2V K. Houshang Pour Islam

Abstract
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.
Objective

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice

The lecture addresses students in the fields of engineering, science and other related technical fields.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
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<tr>
<td>Personal Competencies</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
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851-0783-00L Supervised Research (Law, Economics, and Data Science)

Does not take place this semester.

Abstract

This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from economics and machine learning to questions in law, data science, and social science.

Objective

Apply tools from data science and social science to a new project, potentially in a group, to develop a paper or app.

Prerequisites / notice

Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

Contract Design I

Number 851-0742-00L

<table>
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<tbody>
<tr>
<td>Description</td>
<td>You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for &quot;Contract Design I (851-0742-00L; Fall 2023)&quot; and enroll. The password is &quot;ContractDesign01&quot;.</td>
</tr>
<tr>
<td>Objective</td>
<td>It is NOT a legal drafting class focused on contractual language.</td>
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<tr>
<td>Number of participants limited to 160.</td>
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<tr>
<td>Max 80 ETHZ and 80 UZH Students</td>
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<tr>
<td>Abstract</td>
<td>Contract Design I is taught by Professor Stremitzer and aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place and then engineer contracts that achieve the desired outcome.</td>
</tr>
<tr>
<td>Objective</td>
<td>Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Contract Design will provide you with analytical tools to design contracts that help you be better lawyers, business leaders, and startup founders.</td>
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<td>Number</td>
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<tr>
<td>ECTS</td>
<td>3 credits</td>
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<td>Hours</td>
<td>2V</td>
</tr>
<tr>
<td>Lecturers</td>
<td>A. Stremitzer, A. Tacconelli</td>
</tr>
</tbody>
</table>

Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2615 of 2667
Attendance is mandatory. You are only allowed to miss two lectures unless there are special circumstances.

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT.

If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Problem-solving

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Negotiation

**Personal Competencies**
- Creative Thinking

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**851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector**

*Particularly suitable for students of D-BAUG, D-BIOL, D-BSSE, D-CHAB, D-ITET, D-MAVT.*

**Abstract**
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

**Objective**
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

**Prerequisites / notice**
The lecture addresses students in the fields of engineering, science and other related technical fields.

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**851-0251-00L Psychedelic Science: Psychology Pharmacology Physiology Psychotherapy Philosophy Religion Politics**

**Abstract**
This lecture series covers psychedelic science mainly psychologically, and additionally pharmacologically, physiologically, psychotherapeutically, philosophically, religiously, and politically. All contributions will also be reflected on from the viewpoint of the humanities and psychology.

**Objective**
To provide students with a multidisciplinary introduction to psychedelic science, and to also comprehensively embed this in a reflection from a humanities/psychology viewpoint.
Content

Psychedelic science is a multidisciplinary field of study that involves scholars of the mind and scholars of the natural sciences. In this course, psychedelic science is presented mainly from the point of view of psychology, but will additionally also be considered from the viewpoints of pharmacology, physiology, psychotherapy, philosophy, religion, and politics. All contributions will also be reflected on from the viewpoint of the humanities and psychology. The psychedelic studies treated in this course that involve humans focus on controlled and ethically approved studies where these substances are administered to medically screened, prepared, and supported participants.

Private/illicit use of psychedelics is not a topic of this course.

A psychedelic experience can be characterized as a temporary nonordinary state of consciousness (NSC) that is occasioned by classic (serotonergic) psychedelics such as psilocybin, mescaline, N,N-dimethyltryptamine (DMT), and lysergic acid diethylamide (LSD).

Psychologically, the psychedelic experience can manifest at the perceptual, cognitive, affective, volitional, and somesthetic level. The nonordinary perceptual spectrum ranges from visions (e.g., patterns or beings) to the subjective experience of an all-encompassing oneness, which also transcends the distinction between the perceiver and the perceived. The nonordinary cognitive spectrum ranges from no longer functional thinking to very clear thinking, the nonordinary affective spectrum, for example, from deepest sadness to highest bliss, the nonordinary volitional spectrum from the feeling of being able to somewhat influence what is happening to the feeling of having no longer a will of one's own, and the nonordinary somesthetic spectrum, for example, from feelings of bodily heaviness/compression to feelings of bodily lightness/floating.

Heuristically, as one possibility, a psychological typology of the psychedelic experience can be characterized to fall into three main types: religious-like experiences (which may be interpreted religiously/spiritually by the individuals having them, but may also be interpreted materialistically or agnostically), autobiographical experiences, and tripartite-mind (cognition/affectionation) miscellaneous experiences.

Investigating the psychedelic experience is a worthwhile endeavor as, for instance, certain aspects of this experience have been associated with increased subjective well-being both for healthy individuals as well as for patients – for example, persisting positive effects on attitudes, mood, and behavior in healthy individuals and sustained symptom reduction in individuals suffering from depression, anxiety, and addiction.

Psychedelic science is overall a large multidisciplinary effort that requires collaboration of scholars of the mind and scholars of the natural sciences to advance the scientific knowledge of it. In this spirit, this course will – besides the main lecturer (PD Dr. phil. Kurt Stocker, a psychologist) – also involve further psychedelic-scientific scholars giving individual lectures in their respective field of expertise psychology (PD Dr. phil. Katrin Preller, University of Zurich & Yale University), pharmacology (PD Dr. phil. nat. Dino Luethi, University Hospital Basel; Dr. phil. nat. Deborah Rudin, University Hospital Basel; Prof. Dr. phil. Linda Simmler, University of Basel), physiology (PD Dr. sc. nat. Felix Scholkmann, University of Zurich & University of Bern), psychiatry/psychotherapy (Prof. Dr. med. Gregor Hasler, University of Fribourg; Dr. med. Dr. sc. ETH Milan Scheidegg, University of Zurich), and philosophy (Dr. Peter Sjöstedt-Hughes, University of Exeter). Overall, this course will provide an introduction to the research foundations that have made psychedelic science what it is today, and will also provide an identification of the research frontiers that must be addressed to expand the psychedelic science of tomorrow.

Competencies

Subject-specific Competencies

- Concepts and Theories

Personal Competencies

- Critical Thinking

Prerequisites

- Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

Objective

- Apply tools from data science and social science to a new project, potentially in a group, to develop a paper or app.

851-0763-00L

Supervised Research (Law, Economics, and Data Science)

Supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from economics and machine learning to questions in law, data science, and social science.

Abstract

This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from economics and machine learning to questions in law, data science, and social science.

851-0125-65L

A Sampler of Histories and Philosophies of Mathematics

Particularly suitable for students D-CHAB, D-INFK, D-ITET, D-MATH, D-PHYS

Abstract

This course will review several case studies from the ancient, medieval and modern history of mathematics. The case studies will be analyzed from various philosophical perspectives, while situating them in their historical and cultural contexts.

Objective

- The course aims at:
  1. To introduce students to the historicity of mathematics
  2. To make sense of mathematical practices that appear unreasonable from a contemporary point of view
  3. To develop critical reflection concerning the nature of mathematical objects
  4. To introduce various theoretical approaches to the philosophy and history of mathematics
  5. To open the students' horizons to the plurality of mathematical cultures and practices

851-0157-28L

Life and Death

Particularly suitable for students D-BIOL, D-HEST, D-CHAB, D-LSYS

Abstract

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Objective

- There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and mortality have played a crucial role in this connection. This course aims to explore the relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0125-65L

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Particularly suitable for students D-CHAB, D-INFK, D-ITET, D-MATH, D-PHYS

Abstract

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851-0157-28L

Life and Death

Particularly suitable for students D-BIOL, D-HEST, D-CHAB, D-LSYS

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Objective

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The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

851-0763-00L Supervised Research (Law, Economics, and Data Science)  W  3 credits E. Ash

Abstract
This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-HEST). Students will adapt tools from econometrics and machine learning to questions in law, data science, and social science.

Objective
Students must have some data science and/or statistics experience. Some programming experience in Python, Stata, or R is required.

Prerequisites / notice
Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

851-0745-00L Ethics Workshop: The Impact of Digital Life on Society  W  2 credits E. Vayena, A. Blasimme, J. Sleigh, to be announced

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Competencies
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.

Content
The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focuses on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies).

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

851-0391-00L Focus on the Human: Human-Centered Security and Privacy Lab  W  3 credits V. Zimmermann, A. Toth

Abstract
After an introduction on usable security as the intersection of computer science and psychology, students will form teams and work on exemplary security- or privacy-related research questions. The teams will develop and evaluate a concept for a human-centered solution. Through input sessions and milestone presentations the human perspective will be incorporated and reflected upon.
Objective
The course makes students experience an exemplary human-centered design process. They will learn about and practically apply human-centered design and evaluation methods that will allow them to view their solution from the human perspective, e.g., the user, developer or website owner perspective. By taking part in the evaluation of other teams, they will also take the user perspective themselves.

Content
At the beginning of the course, the students will receive an introduction to usable IT security and privacy and relevant concepts. Afterwards, a selection of current research questions from that area will be presented. The students form teams and select one of the proposed research questions. This question will accompany the students throughout the semester. They will design and evaluate a concept for a human-centered solution to that question. To be able to do so, they will receive input on human-centered design and evaluation tools. Their progress and the inclusion of the human perspective will be subject to feedback in milestone presentations. The students’ human-centered solution can take the form of a concept (e.g., a concept for a product or app), interface (e.g., a visual or tangible interface), or prototype (e.g., sketches, a click-dummy or a built prototype). The solution will then be subject to evaluations. The solutions will be user-tested by members of other teams that thereby take the perspective of a user themselves. In addition, the solutions will be analyzed from different stakeholders’ perspectives, such as developers or website owners. Finally, the students will reflect on potential changes that results from the evaluations and their consequences.

Literature


Prerequisites / notice
This course is especially recommended after the related lecture "851-0390-00 G Human-Centered IT Security and Privacy". However, previous participation in the lecture is not a requirement and not necessary for succeeding in the course.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<th>Analytical Competencies</th>
<th>Decision-making</th>
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<td>Self-direction and Self-management</td>
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851-0251-00L Psychedelic Science: Psychology Pharmacology Physiology Psychotherapy Philosophy Religion Politics

Abstract
This lecture series covers psychedelic science mainly psychologically, and additionally pharmacologically, physiologically, psychotherapeutically, philosophically, religiously, and politically. All contributions will also be reflected on from the viewpoint of the humanities and psychology.

Objective
To provide students with a multidisciplinary introduction to psychedelic science, and to also comprehensively embed this in a reflection from a humanities/psychology viewpoint.
The main objectives of the course are to enable students to 1) identify the ways in which human values and developments of AI and society are entangled, 2) articulate what is significant about contemporary transformations in AI and society, and 3) participate and shape the relationship between human values and AI as citizens and professionals.

Heuristically, as one possibility, a psychological typology of the psychedelic experience can be characterized to fall into three main types of religious-like experiences (which may be interpreted religiously/spiritually by the individuals having them, but may also be interpreted materialistically or agnostically), autobiographical experiences, and tripartite-mind (cognition/affectionation) miscellaneous experiences.

Investigating the psychedelic experience is a worthwhile endeavor as, for instance, certain aspects of this experience have been associated with increased subjective well-being both for healthy individuals as well as for patients – for example, persisting positive effects on attitudes, mood, and behavior in healthy individuals and sustained symptom reduction in individuals suffering from depression, anxiety, and addiction.

Psychedelic science is overall a large multidisciplinary effort that requires collaboration of scholars of the mind and scholars of the natural sciences to advance the scientific knowledge of it. In this spirit, this course will – besides the main lecturer (PD Dr. phil. Kurt Stocker, a psychologist) – also involve further psychedelic-scientific scholars giving individual lectures in their respective field of expertise psychology (PD Dr. phil. Katrin Preller, University of Zurich & Yale University), pharmacology (Dr. phil. nat. Ulrich Uhl, University Hospital Basel; Dr. phil. nat. Deborah Rudin, University Hospital Basel; Prof. Dr. phil. Linda Simmler, University of Basel), physiology (PD Dr. sc. nat. Felix Scholkmann, University of Zurich & University of Bern), psychitrapsychotherapy (Prof. Dr. med. Gregor Hasler, University of Fribourg; Dr. med. sc. ETH Milan Scheidegger, University of Zurich), and philosophy (Dr. Peter Sjöstedt-Hughes, University of Exeter). Overall, this course will provide an informative overview of the research foundations that have made psychedelic science what it is today, and will also provide an identification of the research frontiers that must be addressed to expand the psychedelic science of tomorrow.
Rapid advances in the technologies and empirical approaches used in imaging the human brain have opened exciting windows into how the human brain coordinates social interaction. These advances include imaging the brain’s function during real social interactions, training behaviors with feedback based on real-time brain activity, and even generating art directly from brain signals. With them, these advances have brought novel ethical implications regarding their implementation in research and potentially, their use by the public, for both therapeutic and possible "neurohacking" applications. In this seminar, students will be introduced to various neuroimaging approaches for social neuroscience generally, as well as to approaches for measuring social brain function in real life, and will gain insights into related ethical considerations.

The seminar builds on the active participation of students in reading, presenting, and critically discussing selected papers in the field. In a final small-group assignment, students are required to integrate and elaborate upon topics covered in the seminar by presenting and debating a novel research proposal for addressing a timely research question related to the use of brain imaging in the context of social interactions. No prior experience or knowledge in brain imaging is required.

### Competencies

#### Subject-specific Competencies
- Concepts and Theories fostered
- Techniques and Technologies fostered

#### Method-specific Competencies
- Analytical Competencies fostered
- Decision-making fostered
- Media and Digital Technologies fostered
- Problem-solving fostered
- Project Management fostered

#### Social Competencies
- Communication assessed
- Cooperation and Teamwork fostered
- Customer Orientation fostered
- Leadership and Responsibility fostered
- Self-presentation and Social Influence fostered
- Sensitivity to Diversity fostered

#### Personal Competencies
- Negotiation fostered
- Adaptability and Flexibility fostered
- Creative Thinking fostered
- Critical Thinking assessed
- Integrity and Work Ethics fostered
- Self-awareness and Self-reflection fostered
- Self-direction and Self-management assessed

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**851-0392-00L**

**Privacy Quantification and Usable Protection Mechanisms**

**W 3 credits 2S N. Zufferey, V. Zimmermann**

**Abstract**

Students will gain an overview of the main privacy metrics that are used to evaluate privacy risks related to the use of a given technology. They will also be introduced to the concepts of privacy/utility balance and usable security. Practical exercises and reading of recently published scientific articles will be used to present practical cases of the theoretical tools presented in class.

**Objective**

This course aims to provide students with a global knowledge of the concepts related to privacy, and the methodology and tools to identify, analyze, and address threats while taking the user into account in the process. They will adopt a “privacy mindset”, thus enabling them to automatically take privacy into account, in a usable way, when designing or analyzing a system.

**Content**

First, the course will introduce the different definitions and approaches of privacy (e.g., privacy by control, privacy by design) as well as the ethical concerns and considerations related to information security and privacy research (e.g., responsible disclosure, full disclosure).

Second, the students will be introduced to the different methods, properties, and metrics to assess and/or guarantee a certain level of privacy. They will be introduced to the properties and metrics related to anonymization (e.g., k-anonymity, l-diversity), data aggregation (e.g., randomized responses, ε-differential privacy), as well as other privacy assessment methodologies (e.g., inferential privacy).

Third, the course will address usability issues and the role of individuals (i.e., users) in privacy management (i.e., usable security and privacy) and the design of privacy-enhancing technologies. In this context, we will analyze the main concepts seen during the course and discuss their advantages and disadvantages in terms of usability, as well as their implementation for mass-market and large-scale technologies.

Across all three parts of the course, practical exercises, as well as recent research articles reading, and presentations will be used as a complement to support the concepts seen in class, as well as to provide concrete examples of methodologies related to the assessment of privacy in general.

**Literature**


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**851-0271-00L**

**Neuroaesthetics - Exploring the Science of Aesthetic Experience**

**W 2 credits 2S E. Cross, I. Bara**

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Data: 02.07.2024 12:39 Autumn Semester 2024 Page 2621 of 2667
Abstract
This seminar introduces students to theory and research, challenges, and opportunities in neuroaesthetics, with a clear emphasis on the interdisciplinary nature of the discipline situated at the intersection of neuroscience, psychology, and art appreciation. Foundational empirical methods and critical perspectives of research approaches in neuroaesthetics are considered.

Objective
- to familiarize students with concepts, models, methods, brain and behavioral findings related to aesthetic experience.
- to develop a critical understanding in evaluating the theoretical and empirical findings in neuroaesthetics
- to integrate the acquired knowledge to critically debate and discuss the conceptual and empirical issues related to the science of aesthetic experience

Content
In this seminar, students will learn about the foundational principles of neuroaesthetics, which explores the cognitive and brain processes involved in aesthetic experience. A key focus will be placed on developing an appreciation of the interdisciplinary methods used in the neuroaesthetics field – ranging from neuroscience, psychology, philosophy, and art history. The seminar is based on the active engagement of students in reading, presenting, and critically discussing selected papers in the field. In a final small-group assignment, students are expected to incorporate and elaborate upon the content covered in the seminar by presenting and discussing a novel research proposal for tackling a timely research question related to aesthetic experience.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking fostered
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

D-INFK

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<td>851-0252-01L</td>
<td>Human-Computer Interaction: Cognition and Usability</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>C. Hölscher, I. Barisic, B. Davison</td>
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<td>Particularly suitable for students of D-ARCH, D-INFK, D-ITET.</td>
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Abstract
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability, with a focus on applying them to real situations.

Objective
Presentations will cover the basics of human-computer interaction and selected topics:
- History of HCI
- Research ethics
- Literature reviews
- Participant-free methods: cognitive walkthrough and heuristic evaluation
- Card sorting and information architecture
- Usability studies
- Unmoderated research and diary studies
- Surveys
- User Logs and metric frameworks

On a weekly basis, students will conduct authentic research in class covering the topics above. They will submit their in-class research results regularly and also present their findings to the class once per semester.

The final project demonstrates class topic adoption by deeply exploring one HCI problem using the covered methods and tools. Students will choose a research topic and execute their research plan. They will individually write a formal report including problem definition, literature review, methodology, findings and discussion.

851-0742-00L | Contract Design I | W    | 3    | 2V    | A. Stremitzer, A. Tacconelli |
|             |                   |      |      |       |                          |

Abstract
Contract Design I is taught by Professor Stremitzer and aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place and then engineer contracts that achieve the desired outcome.
Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Contract Design will provide you with analytical tools to design contracts that help you be better lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie financing, production & distribution, construction & development, M&A deals, venture capital financing, to executive compensation and many other types of transactions.

The course follows a flipped-classroom model: You will watch learning videos specifically produced for this course ahead of class. We will use class time to discuss real-world case studies. The videos will be made available before the lecture each week and need to be watched ahead of coming to class. Computer-graded quizzes at the beginning of each class will test students’ understanding of the concepts introduced in the videos.

As the emphasis of this class is on class discussion, attendance is mandatory. Absent important reasons, you cannot miss class more than twice.

The lectures will be recorded but only made available to those who miss lectures with excused absence.

For ETH students: Your grade will consist of two parts:
1) You will take weekly computer-based quizzes during class time. Thus, it is important that you attend the lectures to be able to finish the quizzes and pass this course.
2) You compose short responses to take-home questions on case studies we assign and upload them ahead of class (Pass/Fail).

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH students also have to complete an additional group project. UZH and UNISG students should check out the description of the class at their respective home institutions.

Lecture notes
Handouts, prerecorded videos, slides, case studies, and other materials available on a dedicated webpage: contractdesign.org. Access to this webpage is free of charge for ETH students as ETH purchased a license for ETH students. UZH and UNISG students can access the course materials via their respective institutional license agreements.

Prerequisites / notice
Attendance is mandatory. You are only allowed to miss two lectures unless there are special circumstances.

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT.

If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@geiss.ethz.ch) or Serge von Steiger (serge.vonsteiger@geiss.ethz.ch).

Competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Negotiation assessed

Personal Competencies
- Creative Thinking assessed

Content

The objective is knowing and understanding key legal concepts relevant for doing e-business, in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.

1) Welches Recht gilt im E-Business?
- Internationalität des Internets
- Regulierte Branchen

2) Gestaltung und Vermarktung von E-Business-Angeboten
- Verwendung fremder und Schutz der eigenen Inhalte
- Haftung im E-Business (und wie sie beschränkt werden kann)
- Domain-Namen

3) Beziehung zu E-Business-Kunden
- Verträge im E-Business, Konsumentenschutz
- Elektronische Signaturen
- Datenschutz
- Spam

4) Verträge mit E-Business-Providern

Änderungen, Umstellungen und Kürzungen bleiben vorbehalten. Der aktuelle Termin- und Themenplan ist zu gegebener Zeit über Moodle abrufbar.
Social Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks, including statistical and mathematical methods. In this course, the emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

### Objective

The following topics will be covered:

- Introduction to network models and their applications
- Stylized models:
  - uniform random graph models
  - small world models
  - preferential attachment models
- Models for testing hypotheses while controlling for the network structure:
  - Quadratic assignment procedure regression (QAP regression)
- Models for testing hypotheses on the network structure:
  - Models for one single observation of a network: exponential random graph models (ERGMs)
  - Models for panel network data: stochastic actor-oriented models (SAOMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

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- Models for testing hypotheses on the network structure:
  - Models for one single observation of a network: exponential random graph models (ERGMs)
  - Models for panel network data: stochastic actor-oriented models (SAOMs)
  - Models for relational event data: dynamic network actor models (DyNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

### Literature


### Prerequisites

Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

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**851-0252-13L**  
**Network Modeling**  
*Particularly suitable for students of D-MATH, D-INFK and in the MSc Data Science*

Students are required to have basic knowledge in inferential statistics, such as regression models.

### Abstract

Social Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks, including statistical and mathematical methods. In this course, the emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

### Objective

Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

### Content

The following topics will be covered:

- Models for testing hypotheses while controlling for the network structure:
  - Quadratic assignment procedure regression (QAP regression)
  - Models for testing hypotheses on the network structure:
    - Models for one single observation of a network: exponential random graph models (ERGMs)
    - Models for panel network data: stochastic actor-oriented models (SAOMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

### Literature


### Prerequisites

Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.
The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

- Empirical Research and Network Data
- Macro and Micro Structure
- Centrality
- Roles
- Cohesion
- Influence

Lecture notes and lecture notes are distributed via the associated course moodle.

Literature


Competencies

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851-0732-06L Law & Tech W 3 credits 2S A. Stremitzer, J. Merane

Abstract

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective

The course is designed for a wide range of ETH students as well as for law students who are keen to deepen their understanding of cutting-edge technology. It offers an overview of key legal areas important for technology regulation, complemented by guest lectures on emerging technological trends.

In previous years, the course has featured esteemed speakers from various sectors, including industry leaders like Google, NGOs such as Digital Society Switzerland and The European Consumer Organization, regulatory bodies like the Swiss Competition Commission, and noted academics.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content

The planned course outline is below.

- Overview of Law and Technology
- Fundamental Rights
- AI & Discrimination
- Landmark Big Tech Cases
- Regulation of Digital Platforms & Content Moderation
- Online Consumer Protection
- Law and Tech Scholarship Series

A number of recent regulations will be discussed, including the EU's AI Act, the Digital Services Act (DSA), and the Digital Markets Act (DMA), as well as emerging internet phenomena, like ChatGPT.

Prerequisites / notice

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Law & Tech (851-0732-06L, HS 2024)" and enroll.

Competencies

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851-0101-86L Complex Social Systems: Modeling Agents, Learning, and Games W 3 credits 2S D. N. Dalilisan, D. Carpentras, D. Helbing

Prerequisites: Basic programming skills, elementary probability and statistics.

Abstract

This course introduces mathematical and computational models to study techno-socioeconomic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and to communicate their results through a project report and a short oral presentation.

Objective

See your own field of study in a wider context ("Science in Perspective"), e.g. see the psychological, social, economic, environmental, historical, ethical, or philosophical connections and implications. Learn to think critically and out of the box. Question what you believe you know for sure. Get to know surprising, counterintuitive properties of complex (non-linearly interacting, networked, multi-component) systems. Learn about collaboration.
By the end of the course, the students should be able to better understand the literature on complex social systems, develop their own models for studying specific phenomena and report results according to the standards of the relevant scientific literature by presenting their results both numerically and graphically.

At the end of the course, the students will deliver a report, computer code and a short oral presentation. To collect credit points, students will have to actively contribute and give a circa 30 minutes presentation in the course on a subject agreed with the lecturers, after which the presentation will be discussed. The presentation will be graded.

Students are expected to implement themselves models of techno-socio-economic processes and systems, particularly agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature, its presentation, and documentation by a project report.

The lecture slides will be presented on the course Moodle after each lecture.

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.
Content

Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

851-0467-00L

From Traffic Modeling to Smart Cities and Digital Democracies

Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution.

Objective
To collect credit points, students must actively contribute and give an individual, circa 20-minute presentation in the seminar on a subject agreed upon with the lecturer. After the presentation, it will be discussed and graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.

Literature
Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
Michael Batty, Kay Axhausen et al.
Smart cities of the future
Books by Michael Batty:
How social influence can undermine the wisdom of crowd effect
Evidence for a collective intelligence factor in the performance of human groups
Optimal incentives for collective intelligence
Collective Intelligence: Creating a Prosperous World at Peace
Big Mind: How Collective Intelligence Can Change Our World
Programming Collective Intelligence
Urban architecture as connective-collective intelligence. Which spaces of interaction?
Build digital democracy
How to make democracy work in the digital age
Digital Democracy: How to make it work?
Proof of witness presence: Blockchain consensus for augmented democracy in smart cities
Iterative Learning Control for Multi-agent Systems Coordination
Decentralized Collective Learning for Self-managed Sharing Economies

Prerequisites / notice
Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity

Personal Competencies
Negotiation
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management
Fostered Adaptability and Flexibility

After an introduction on usable security as the intersection of computer science and psychology, students will form teams and work on exemplary security- or privacy-related research questions. The teams will develop and evaluate a concept for a human-centered solution. Through input sessions and milestone presentations the human perspective will be incorporated and reflected upon.

Objective

The course makes students experience an exemplary human-centered design process. They will learn about and practically apply human-centered design and evaluation methods that will allow them to view their solution from the human perspective, e.g., the user, developer or website owner perspective. By taking part in the evaluation of other teams, they will also take the user perspective themselves.

Content

At the beginning of the course, the students will receive an introduction to usable IT security and privacy and relevant concepts. Afterwards, a selection of current research questions from that area will be presented. The students form teams and select one of the proposed research questions. This question will accompany the students throughout the semester. They will design and evaluate a concept for a human-centered solution to that question. To be able to do so, they will receive input on human-centered design and evaluation tools. Their progress and the inclusion of the human perspective will be subject to feedback in milestone presentations. The students' human-centered solution can take the form of a concept (e.g., a concept for a product or app), interface (e.g., a visual or tangible interface), or prototype (e.g., sketches, a click-dummy or a built prototype). The solution will then be subject to evaluations. The solutions will be user-tested by members of other teams that thereby take the perspective of a user themselves. In addition, the solutions will be analyzed from different stakeholders' perspectives, such as developers or website owners. Finally, the students will reflect on potential changes that results from the evaluations and their consequences.

Literature


Prerequisites / notice

This course is especially recommended after the related lecture "851-0390-00 G Human-Centered IT Security and Privacy". However, previous participation in the lecture is not a requirement and not necessary for succeeding in the course.

Competencies

Subject-specific Competencies

- Concepts and Theories: fostered

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: fostered
- Problem-solving: assessed
- Project Management: assessed

Social Competencies

- Communication: fostered
- Cooperation and Teamwork: assessed
- Customer Orientation: fostered
- Sensitivity to Diversity: fostered

Personal Competencies

- Adaptability and Flexibility: fostered
- Creative Thinking: fostered
- Critical Thinking: fostered
- Integrity and Work Ethics: fostered
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: fostered
The growing presence of AI tools for public use, for public administration, inside corporations and in scientific research raises many questions about the ethical, political, legal consequences of these technologies. This course is built around multiple sites of encounter among human values and AI, including bodies, persons, cities, labs, law, and environment. In each site, we inquire about what and whose values are being prioritized and with what consequences. The course also investigates existing best-practices around how to "align" human values with AI (e.g., human-centric design, alignment, reproducibility, transparency, explainability) and introduces students to regimes of ethics and governance of AI being proposed in jurisdictions around the world. Students learn to unpack the values and assumptions in existing techniques and frameworks for the design and governance of AI and to engage constructively with diverse stakeholders to shape the human-technology future towards aims that are reflexive, responsible, and democratic.

851-0272-00L The Cutting Edge of Social Brain Imaging W 2 credits 2S E. Cross, R. Moffat

Abstract
This seminar introduces the fundamentals and latest research developments of brain imaging in real-world contexts. We explore topics from imaging multiple people’s brains simultaneously as they interact to neuro-ethics and neuro-art, while maintaining a strong focus on critical evaluation of research practices and applications of brain imaging of and during social interaction.

Objective
- To familiarize students with current concepts, theories, methods, and findings from social brain-imaging sciences
- To develop a critical view of extant findings and the tools for evaluating the quality of evidence and data, as well as ethical implications

Content
Rapid advances in the technologies and empirical approaches used in imaging the human brain have opened exciting windows into how the human brain coordinates social interaction. These advances include imaging the brain’s function during real social interactions, training behaviours with feedback based on real-time brain activity, and even generating art directly from brain signals. With them, these advances have brought novel ethical implications regarding their implementation in research and potentially, their use by the public, for both therapeutic and possible “neurohacking” applications. In this seminar, students will be introduced to various neuroimaging approaches for social neuroscience generally, as well as to approaches for measuring social brain function in real life, and will gain insights into related ethical considerations.

The seminar builds on the active participation of students in reading, presenting, and critically discussing selected papers in the field. In a final small-group assignment, students are required to integrate and elaborate upon topics covered in the seminar by presenting and debating a novel research proposal for addressing a timely research question related to the use of brain imaging in the context of social interactions. No prior experience or knowledge in brain imaging is required.

Competencies
Subject-specific Competencies
Concepts and Theories fostered
Techniques and Technologies fostered

Method-specific Competencies
Analytical Competencies fostered
Decision-making fostered
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management assessed

851-0392-00L Privacy Quantification and Usable Protection Mechanisms W 2 credits 2S N. Zufferey, V. Zimmermann

Abstract
Students will gain an overview of the main privacy metrics that are used to evaluate privacy risks related to the use of a given technology. They will also be introduced to the concepts of privacy/utility balance and usable security. Practical exercises and reading of recently published scientific articles will be used to present practical cases of the theoretical tools presented in class.

Objective
This course aims to provide the students with a global knowledge of the concepts related to privacy, and the methodology and tools to identify, analyze, and address threats while taking the user into account in the process. They will adopt a "privacy mindset", thus enabling them to automatically take privacy into account, in a usable way, when designing or analyzing a system.

Content
First, the course will introduce the different definitions and approaches of privacy (e.g., privacy by control, privacy by design) as well as the ethical concerns and considerations related to information security and privacy research (e.g., responsible disclosure, full disclosure).

Second, the students will be introduced to the different methods, properties, and metrics to assess and/or guarantee a certain level of privacy. They will be introduced to the properties and metrics related to anonymization (e.g., k-anonymity, l-diversity), data aggregation (e.g., randomized responses, ε-differential privacy), as well as other privacy assessment methodologies (e.g., inferential privacy).

Third, the course will address usability issues and the role of individuals (i.e., users) in privacy management (i.e., usable security and privacy) and the design of privacy-enhancing technologies. In this context, we will analyze the main concepts seen during the course and discuss their advantages and disadvantages in terms of usability, as well as their implementation for mass-market and large-scale technologies.

Across all three parts of the course, practical exercises, as well as recent research articles reading, and presentations will be used as a complement to support the concepts seen in class, as well as to provide concrete examples of methodologies related to the assessment of privacy in general.
Technology stands for innovation and catastrophes; it works as a dream machine and is associated with the most diverse ways of
fostered

Concepts and Theories
assessed

Techniques and Technologies
assessed

Method-specific Competencies

Analytical Competencies
fostered

Social Competencies

Communication
fostered

Personal Competencies

Creative Thinking
fostered

Critical Thinking
fostered

Integrity and Work Ethics
fostered

Subject-specific Competencies

Concepts and Theories
fostered

Techniques and Technologies
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Analytical Competencies
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Decision-making
fostered

Media and Digital Technologies
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Problem-solving
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Project Management
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Creative Thinking
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Critical Thinking
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Integrity and Work Ethics
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Self-awareness and Self-reflection
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Self-direction and Self-management
fostered

WebClass Introductory Course History of Technology

Particularly suitable for students D-BAUG, D-INFK, D-ITET, D-MATL, D-MAVT.

Technology stands for innovation and catastrophes; it works as a dream machine and is associated with the most diverse ways of
utilization. In WebClass Introductory Course History of Technology students become familiar with explanations for how technology works
within complex economic, political and cultural contexts, by interpreting and researching texts and authoring a student manual.

Students are introduced into how technological innovations take place within complex economic, political and cultural contexts. They get to
know basic theories and practices of the field by acquiring the skills to interpret texts, to compare arguments, to research additional sources and
complementary material and to author a common essay. All of this will yield into a student manual on the four core topics: technology
and innovation, technology and catastrophes, technology as a dream machine and technology and association. The course language is
German, and even if many texts will be in English, the ability to read and understand German is mandatory.

Technik steht für Innovation und Katastrophen, sie dient als Wunschmaschine und ist mit unterschiedlichsten Nutzungsformen assoziiert.

Die WebClass Technikhistorik ist ein webgestützter Einführungskurs, der um die technikhistorischen Grundthemen kreist.

Technikhistorik untersucht Angebote technischer Entwicklungen, die in bestimmten historischen Kontexten entstanden und von
sozialtechnischen, politischen und wirtschaftlichen Bedingungen geprägt wurden. Die Studierenden lernen, sich in jene Auseinandersetzungen einzudunkeln, die soziotechnische Veränderungen stets begleiten. Sie interpretieren Texte, vergleichen Argumente, recherchieren alte und neue Darstellungen und verfassen in Gruppen
einen Beitrag zu ihrem eigenen Manual der Technikhistorik. Der Onlinekurs wird in zwei obligatorischen Präsenzveranstaltungen –
einer Einführungssitzung und einem Redaktionsmeeting – begleitet. Die aktive Teilnahme und das erfolgreiche Bearbeiten von
Onlineaufgaben (Verfassen von Texten) werden vorausgesetzt.

Informationen zur Arbeit mit der WebClass Technikhistorik finden Sie unter https://www.tg.ethz.ch/programme/lehreprogramm/webclass-
einfuehrungskurs. Sobald Sie eingeschrieben sind, haben Sie Zugang zum Online-Kurs auf Moodle mit den Aufgaben und den
weiterführenden Materialien.
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined. The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via Moodle platform for a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

Credits and Exam
After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. Students who obtain a grade of < 4.0 for the test will have a second chance (see table below). Students who did not participate in the test on 18 December 2023 will not have access to the repeat test unless they submit compelling and documented (e.g. medical, other exam in parallel at ETH) reasons for why they were unable to participate in the first test. It covers all contents of the lectures and the reading assignments. Visiting students (e.g., from the University of Zurich or other universities) are subject to the same conditions. Registration for the course in the mystudies system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.

Competencies
Subject-specific Competencies
- Concepts and Theories
  - understood

Method-specific Competencies
- Analytical Competencies
- Problem-solving
  - understood

Personal Competencies
- Creative Thinking
- Critical Thinking

Lecture notes
Reading materials and slides will be available via Moodle.

Prerequisites / notice
The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy.
### 851-0252-01L Human-Computer Interaction: Cognition and Usability

**W 3 credits 2S**

**C. Hölscher, I. Barisic, B. Davison**

**Abstract**
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability, with a focus on applying them to real situations.

**Objective**
Presentations will cover the basics of human-computer interaction and selected topics:
- History of HCI
- Research ethics
- Literature reviews
- Participant-free methods: cognitive walkthrough and heuristic evaluation
- Card sorting and information architecture
- Usability studies
- Unmoderated research and diary studies
- Surveys
- User Logs and metric frameworks

On a weekly basis, students will conduct authentic research in class covering the topics above. They will submit their in-class research results regularly and also present their findings to the class once per semester.

The final project demonstrates class topic adoption by deeply exploring one HCI problem using the covered methods and tools. Students will choose a research topic and execute their research plan. They will individually write a formal report including problem definition, literature review, methodology, findings and discussion.

**Competencies**

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**851-0735-10L Startups and Law**

**W 2 credits 2S**

**P. Peyrot**

**Abstract**
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

**Objective**
The students shall obtain the following competence:
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

**Competencies**

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**851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector**

**W 2 credits 2V**

**K. Houshang Pour Islam**

**Abstract**
The lecture gives an overview of the fundamental aspects of intellectual property, which play an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

**Objective**
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of intellectual property in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

**Prerequisites / notice**
The lecture addresses students in the fields of engineering, science and other related technical fields.
### Complex Social Systems: Modeling Agents, Learning, and Games  
851-0101-86L  

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**Abstract**  
This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and to communicate their results through a project report and a short oral presentation.

**Objective**  
See your own field of study in a wider context ("Science in Perspective"), e.g. see the psychological, social, economic, environmental, historical, ethical, or philosophical connections and implications. Learn to think critically and out of the box. Question what you believe you know for sure. Get to know surprising, counterintuitive properties of complex (non-linearly interacting, networked, multi-component) systems. Learn about collaboration.

**Content**  
By the end of the course, the students should be able to better understand the literature on complex social systems, develop their own models for studying specific phenomena and report results according to the standards of the relevant scientific literature by presenting their results both numerically and graphically.

At the end of the course, the students will deliver a report, computer code and a short oral presentation. To collect credit points, students will have to actively contribute and give a circa 30 minutes presentation in the course on a subject agreed with the lecturers, after which the presentation will be discussed. The presentation will be graded.

Students are expected to implement themselves models of techno-socio-economic processes and systems, particularly agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature, its presentation, and documentation by a project report.

**Lecture notes**  
The lecture slides will be presented on the course Moodle after each lecture.

**Literature**  
- Agent-Based Modeling  
  https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2
- Social Self-Organization  
- Traffic and related self-driven many-particle systems  
  Reviews of Modern Physics 73, 1067  
  https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067
- An Analytical Theory of Traffic Flow (collection of papers)  
  https://www.researchgate.net/publication/281629187
- Pedestrian, Crowd, and Evacuation Dynamics  
  https://www.research-collection.ethz.ch/handle/20.500.11850/45424
- The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)  
  https://science.sciencemag.org/content/342/6164/1337

**Prerequisites / notice**  
The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

### Building a Robot Judge: Data Science for Decision-Making  
851-0760-00L  

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**Abstract**  
Does not take place this semester. Particularly suitable for students of D-INFK, D-ITET, D-

**Lecture notes**  
The lecture slides will be presented on the course Moodle after each lecture.

**Literature**  
- Building a Robot Judge: Data Science for Decision-Making  
  Does not take place this semester. Particularly suitable for students of D-INFK, D-ITET, D-

**Prerequisites / notice**  
- Good programming skills and a good understanding of probability & statistics and calculus are expected.
- Students need to present a new subject, for which they have not earned any credit points before.
- Good scientific practices, in particular citation and quotation rules, must be properly complied with.
- Chatham House rules apply to this course. Materials may not be shared without previous written permission.
MTEC.

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

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851-0467-00L From Traffic Modeling to Smart Cities and Digital Democracies

Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution.

Objective
To collect credit points, students must actively contribute and give an individual, circa 20-minute presentation in the seminar on a subject agreed upon with the lecturer. After the presentation, it will be discussed and graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.

Literature
Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
Michael Batty, Kay Axhausen et al.
Smart cities of the future
Books by Michael Batty:
How social influence can undermine the wisdom of crowd effect
Evidence for a collective intelligence factor in the performance of human groups
Optimal incentives for collective intelligence
Collective Intelligence: Creating a Prosperous World at Peace
Big Mind: How Collective Intelligence Can Change Our World
Programming Collective Intelligence
Urban architecture as connective-collective intelligence. Which spaces of interaction?
Build digital democracy
How to make democracy work in the digital age
Digital Democracy: How to make it work?
Proof of witness presence: Blockchain consensus for augmented democracy in smart cities
Iterative Learning Control for Multi-agent Systems Coordination
Decentralized Collective Learning for Self-managed Sharing Economies
Prerequisites / notice
Students need to present a new subject, for which they have not earned any credit points before.
Good scientific practices, in particular citation and quotation rules, must be properly complied with.
Chatham House rules apply to this course. Materials may not be shared without previous written permission.
The course is designed for a wide range of ETH students as well as for law students who are keen to deepen their understanding of cutting-edge technology. It offers an overview of key legal areas important for technology regulation, complemented by guest lectures on emerging technological trends.

In previous years, the course has featured esteemed speakers from various sectors, including industry leaders like Google, NGOs such as Digital Society Switzerland and The European Consumer Organization, regulatory bodies like the Swiss Competition Commission, and noted academics.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content

The planned course outline is below.

- Overview of Law and Technology
- Fundamental Rights
- AI & Discrimination
- Landmark Big Tech Cases
- Regulation of Digital Platforms & Content Moderation
- Online Consumer Protection
- Law and Tech Scholarship Series

A number of recent regulations will be discussed, including the EU's AI Act, the Digital Services Act (DSA), and the Digital Markets Act (DMA), as well as emerging internet phenomena, like ChatGPT.

Prerequisites / notice

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Law & Tech (851-0732-06L, HS 2024)" and enroll.

Competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Communication</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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851-0391-00L Focus on the Human: Human-Centered Security and Privacy Lab

The course is particularly suitable for all students who have already completed the course "Human-centered IT Security and Privacy" as some of the concepts introduced will practically be applied in this course. However, the relevant literature and necessary material will be provided so that all interested students can participate.

Abstract

After an introduction on usable security as the intersection of computer science and psychology, students will form teams and work on exemplary security- or privacy-related research questions. The teams will develop and evaluate a concept for a human-centered solution. Through input sessions and milestone presentations, the human perspective will be incorporated and reflected upon.

Objective

The course makes students experience an exemplary human-centered design process. They will learn about and practically apply human-centered design and evaluation methods that will allow them to view their solution from a human perspective, e.g., the user, developer, or website owner perspective. By taking part in the evaluation of other teams, they will also take the user perspective themselves.

Content

At the beginning of the course, the students will receive an introduction to usable IT security and privacy and relevant concepts. Afterwards, a selection of current research questions from that area will be presented. The students form teams and select one of the proposed research questions. This question will accompany the students throughout the semester. They will design and evaluate a concept for a human-centered solution to this question. To be able to do so, they will receive input on human-centered design and evaluation tools. Their progress and the inclusion of the human perspective will be subject to feedback in milestone presentations.

The students' human-centered solution can take the form of a concept (e.g., a concept for a product or app), interface (e.g., a visual or tangible interface), or prototype (e.g., sketches, a click-dummy or a built prototype). The solution will then be subject to evaluations. The solutions will be user-tested by members of other teams that thereby take the perspective of a user themselves. In addition, the solutions will be analyzed from different stakeholders' perspectives, such as developers or website owners.

Finally, the students will reflect on potential changes that result from the evaluations and their consequences.
The growing presence of AI tools for public use, for public administration, inside corporations and in scientific research raises many assessed questions about the ethical, political, legal consequences of these technologies. This course is built around multiple sites of encounter among human values and AI, including bodies, persons, cities, labs, law, and environment. In each site, we inquire about what and whose values are being prioritized and with what consequences. The course also investigates existing best-practices around how to "align" human values with AI (e.g. human-centric design, alignment, reproducibility, transparency, explainability) and introduces students to regimes of ethics and governance of AI being proposed in jurisdictions around the world. Students learn to unpack the values and assumptions in existing techniques and frameworks for the design and governance of AI and to engage constructively with diverse stakeholders to shape the relationship between human values and AI as citizens and professionals.

This course introduces students to the ethical, political and legal debates and transformations in relation to Artificial Intelligence and provides students with concepts and methods from the constructivist and interpretive social sciences to work towards responsible and democratic human-technology futures.

This course aims to provide the students with a global knowledge of the concepts related to privacy, and the methodology and tools to use them to automatically take privacy into account, in a usable way, when designing or analyzing a system. They will also be introduced to the concepts of privacy/utility balance and usable security. Practical exercises and reading of recently published scientific articles will be used to present practical cases of the theoretical tools presented in class.

This course aims to provide the students with a global knowledge of the concepts related to privacy, and the methodology and tools to identify, analyze, and address threats while taking the user into account in the process. They will adopt a "privacy mindset", thus enabling them to automatically take privacy into account, in a usable way, when designing or analyzing a system.
First, the course will introduce the different definitions and approaches of privacy (e.g., privacy by control, privacy by design) as well as the ethical concerns and considerations related to information security and privacy research (e.g., responsible disclosure, full disclosure).

Second, the students will be introduced to the different methods, properties, and metrics to assess and/or guarantee a certain level of privacy. They will be introduced to the properties and metrics related to anonymization (e.g., k-anonymity, l-diversity), data aggregation (e.g., randomized responses, $\varepsilon$-differential privacy), as well as other privacy assessment methodologies (e.g., inferential privacy).

Third, the course will address usability issues and the role of individuals (i.e., users) in privacy management (i.e., usable security and privacy) and the design of privacy-enhancing technologies. In this context, we will analyze the main concepts seen during the course and discuss their advantages and disadvantages in terms of usability, as well as their implementation for mass-market and large-scale technologies.

Across all three parts of the course, practical exercises, as well as recent research articles reading, and presentations will be used as a complement to support the concepts seen in class, as well as to provide concrete examples of methodologies related to the assessment of privacy in general.

### Literature


### Competencies

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Communication

**Social Competencies**

- Critical Thinking
- Integrity and Work Ethics

**Personal Competencies**

- Creative Thinking
- Communication

### Content

**WebClass Introductory Course History of Technology**

**W** 3 credits 2V  R. Wichum

**Abstract**

**Subject-specific Competencies**

- Concepts and Theories assessed
- Techniques and Technologies assessed

**Method-specific Competencies**

- Analytical Competencies fostered
- Communication fostered

**Social Competencies**

- Critical Thinking fostered
- Integrity and Work Ethics fostered

**Personal Competencies**

- Creative Thinking fostered

**Language**

German, and even if many texts will be in English, the ability to read and understand German is mandatory.

**Number of participants limited to 160.**

**Max 80 ETHZ and 80 UZH Students**

**Abstract**

Contract Design I is taught by Professor Stremitzer and aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place and then engineer contracts that achieve the desired outcome.

**Lecture notes**


**D-MATH**

**Number**

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<th>Number</th>
<th>Title</th>
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**Abstract**

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2023)” and enroll. The password is “ContractDesign01”.

It is NOT a legal drafting class focused on contractual language.

Number of participants limited to 160.

Max 80 ETHZ and 80 UZH Students

Contract Design I is taught by Professor Stremitzer and aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place and then engineer contracts that achieve the desired outcome.

Data: 02.07.2024 12:39  Autumn Semester 2024  Page 2637 of 2667
Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract design scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Contract Design will provide you with analytical tools to design contracts that help you be better lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie financing, production & distribution, construction & development, M&A deals, venture capital financing, to executive compensation and many other types of transactions.

The course follows a flipped-classroom model: You will watch learning videos specifically produced for this course ahead of class. We will use class time to discuss real-world case studies. The videos will be made available before the lecture each week and need to be watched ahead of coming to class. Computer-graded quizzes at the beginning of each class will test students’ understanding of the concepts introduced in the videos.

As the emphasis of this class is on class discussion, attendance is mandatory. Absent important reasons, you cannot miss class more than twice.

The lectures will be recorded but only made available to those who miss lectures with excused absence.

For ETH students: Your grade will consist of two parts:
1) You will take weekly computer-based quizzes during class time. Thus, it is important that you attend the lectures to be able to finish the quizzes and pass this course.
2) You compose short responses to take-home questions on case studies we assign and upload them ahead of class (Pass/Fail).

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH students also have to complete an additional group project.

UZH and UNISG students should check out the description of the class at their respective home institutions.

Prerequisites / notice
Attendance is mandatory. You are only allowed to miss two lectures unless there are special circumstances.

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT.

If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

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851-0252-15L Network Analysis

Network Analysis is particularly suitable for students of D-INFK, D-MATH.

Abstract
Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Objective
Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

Content
The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

* Empirical Research and Network Data
* Macro and Micro Structure
* Centrality
* Roles
* Cohesion
* Influence

Lecture notes
Slides and lecture notes are distributed via the associated course moodle.

Literature
The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures). We start with an overview of cybersecurity issues from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulatory contexts).

Literature for each session will be available on Moodle.

The lecture is being supported by a website on Moodle.

Literature

The lecture is supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch).

Prerequisites / notice

Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required. Does not take place this semester.

851-0763-00L Supervised Research (Law, Economics, and Data Science)

Abstract

This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from econometrics and machine learning to questions in law, data science, and social science.

Objective

Students must have some data science and/or statistics experience. Some programming experience in Python, Stata, or R is required.

Prerequisites / notice

Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.
Understanding in Science and Mathematics: A Philosophical Perspective

Abstract
Understanding is a central goal of science and mathematics, but what exactly is the nature of scientific and mathematical understanding? In this seminar, we will read and discuss a number of key philosophical contributions on understanding in philosophy of science, philosophy of mathematics, and epistemology. You will also practice your skills in giving clear and engaging oral presentations.

Objective
The main objective of this seminar is to gain an in-depth understanding of the recent literature on understanding in the philosophy of science, the philosophy of mathematics, and epistemology. Another practical objective is to increase your skills in giving clear and engaging oral presentations.

Content
Understanding is a central goal of science and mathematics: scientists seek to understand various phenomena in the natural world, while mathematicians aim to increase our understanding of the mathematical world. But what exactly is the nature of understanding in science and mathematics? This issue has been largely neglected in twentieth century philosophy of science, philosophy of mathematics, and epistemology. Yet, in the past twenty years, there has been a regain of philosophical interest into the notion of understanding, leading to a flourishing literature. The aim of this seminar is to gain an in-depth understanding of these recent philosophical developments.

To this end, we will read a number of key philosophical contributions on understanding in philosophy of science, philosophy of mathematics, and epistemology. Along the way, we will address general issues on understanding such as: What is the relation between understanding and knowledge? Does understanding necessarily require explanation? How can understanding be transmitted? What exactly is the value of understanding? We will also look into specific case studies of scientific and mathematical understanding.

Each session will be decomposed into three blocks. In blocks 1 and 2, we will have a short presentation (~15 minutes) of a contribution in the philosophy of understanding followed by a discussion. Block 3 will be methodological and will be concerned with how to give good oral presentations, an essential skill in academia. We will use this block to debrief on the presentations of the day and see how they could be improved. We will also discuss resources on best practices in oral communication.

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Network Modeling

Abstract
Social Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks, including statistical and mathematical methods. In this course, the emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective
The following topics will be covered:

- Introduction to network models and their applications
  - Stylized models:
    * uniform random graph models
    * small world models
    * preferential attachment models
- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)
- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Content
The following topics will be covered:

- Introduction to network models and their applications
  - Stylized models:
    * uniform random graph models
    * small world models
    * preferential attachment models
- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)
- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)
  * Models for relational event data: dynamic network actor models (DYNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

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Students are required to have basic knowledge in inferential statistics, such as regression models.

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Lecture notes
Slides and lecture notes are distributed via the associated course moodle.


Prerequisites / notice
Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.
Further documents will be available online (https://moodle-app2.let.ethz.ch/course/view.php?id=22904).

**Analytical Competencies**

This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91; the focus here is on current issues in international security policy.

**Social Competencies**

Social Competencies

Communication

Leadership and Responsibility

Sensitivity to Diversity

Negotiation

**Method-specific Competencies**

Method-specific Competencies

Analytical Competencies

Problem-solving

Sensitivity to Diversity

**Subject-specific Competencies**

Subject-specific Competencies

Concepts and Theories

Decision-making

**Literature**

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

World Politics Since 1945: The History of International Relations (Without Exercises)

World Politics Since 1945: The History of International Relations (Without Exercises)

The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

**Objective**

On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

**Literature**

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Further documents will be available online (https://moodle-app2.let.ethz.ch/course/view.php?id=22904).

**Abstract**

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered. The focus is on legal problems related to space. Active participation is expected in short interactive sequences.

**Objective**

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law. They are able to apply the fundamentals in more advanced law classes and to recognize the relevance of law in their own field.

**Content**

Basic concepts of law, sources of law.

Private law: Contract law (particularly contract for work and services), tort law, property law.

Public law: Human rights, administrative law, procurement law, procedural law.

Insights into the law of the EU.

**Lecture notes**

Further documents will be available online (https://moodle-app2.let.ethz.ch/course/view.php?id=22904).

**Prerequisites / notice**

The lecture is being supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch)
853-8002-00L The Role of Technology in National and International Security Policy

Abstract
The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

Objective
Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

Content
- **Part 1** deals with the multifold and complex relationships between national and international concepts and theories. It addresses the significance of technology, including aspects of military capabilities and international dimensions.
- **Part 2** covers the impact of new technologies on military capabilities, strategic options, and security management.
- **Part 3** focuses on regulatory challenges arising from the introduction of new technologies and their global dissemination.

Literature
Literatur für die einzelnen Sitzungen wird auf Moodle bereitgestellt. Für Nachfragen kontaktieren Sie bitte Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch). 

851-0763-00L Supervised Research (Law, Economics, and Data Science)

This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from econometrics and machine learning to questions in law, data science, and social science.

851-0549-00L WebClass Introductory Course History of Technology

Technology stands for innovation and catastrophes; it works as a dream machine and is associated with the most diverse ways of utilization. In WebClass Introductory Course History of Technology, students become familiar with explanations for how technology works within complex economic, political, and cultural contexts, by interpreting and researching texts and authoring a student manual.

851-0252-10L Project in Behavioural Finance

Particularly suitable for students of D-MTEC.

- **Number**: 851-0252-10L
- **Title**: Project in Behavioural Finance
- **Type**: Supervised Research (Law, Economics, and Data Science)
- **ECTS**: 3
- **Hours**: 2S
- **Lecturers**: S. Andrzasewicz, C. Hölscher, A. C. Roberts
In this seminar, students will study cognitive processes, behaviour and the underlying biological response to financial decisions. Research methods such as asset market experiments, lottery games, risk preference assessment, psychometrics, neuroimaging and psychophysiology of decision processes will be discussed. Financial bubbles and crashes will be the core interest.

This course has four main goals:
1) To learn about the most important topics within Behavioural Finance
2) To learn to effectively select, review and present information using modern telecommunication tools
3) To practice working on group projects in hybrid working conditions (online + in-person)
4) To solve an applied behavioral finance business case stemming from an industry partner

The course does not contain mandatory reading. Instead, it offers suggested literature that provides guidance to the students who, prepare a presentation on core topics in behavioral finance. The point of this exercise is to critically select the most relevant information on a given topic and present to non-expert educated colleagues. At the same time, the audience learns about the key topics in behavioral finance. Every session involves a discussion moderated and supported by the lecturers.

Throughout the semester, students work on solutions to real business cases stemming from a company partner. They can receive feedback and guidance from project leaders of the industry partner and from the academic supervisors. In the final meeting of the semester, students pitch solutions to their business cases.

The course takes place entirely online. The objective is to prepare the students for the future work in online and hybrid arrangements.

Students from all domains of ETH and all levels of education are welcome in the course.

This course is only for students enrolled in a Bachelor’s GESS (Science in Perspective):

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<th>Method-specific Competencies</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Customer Orientation</td>
<td>fostered</td>
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<td>fostered</td>
<td>Problem-solving</td>
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<td>assessed</td>
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<td>assessed</td>
<td>Project Management</td>
<td>fostered</td>
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<td>Self-direction and Self-management</td>
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</table>

This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems. This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

The lecture helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

The course Moodle page contains announcements, course information and lecture slides.


This book can also be used for the course '363-0503-00L Principles of Microeconomics’ (Filippini).
degree programme.

Students enrolled in a Master’s degree programme may attend “Principles of Microeconomics” (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed “Principles of Microeconomics” (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature

Prerequisites / notice
This course “Einführung in die Mikroökonomie” (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 “Principles of Microeconomics” for Master students.

Competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies fostered
Problem-solving fostered
Project Management fostered

Social Competencies
Communication fostered
Cooperation and Teamwork fostered
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered

Personal Competencies
Adaptability and Flexibility fostered
Creative Thinking fostered
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

851-0742-00L Contract Design I
W 3 credits 2V A. Stremitzer, A. Tacconelli

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2023)” and enroll. The password is “ContractDesign01”.

It is NOT a legal drafting class focused on contractual language.

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

Abstract
Contract Design I is taught by Professor Stremitzer and aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place and then engineer contracts that achieve the desired outcome.
Objective

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Contract Design will provide you with analytical tools to design contracts that help you be better lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie financing, production & distribution, construction & development, M&A deals, venture capital financing, to executive compensation and many other types of transactions.

The course follows a flipped-classroom model: You will watch learning videos specifically produced for this course ahead of class. We will use class time to discuss real-world case studies. The videos will be made available before the lecture each week and need to be watched ahead of coming to class. Computer-graded quizzes at the beginning of each class will test students’ understanding of the concepts introduced in the videos.

As the emphasis of this class is on class discussion, attendance is mandatory. Absent important reasons, you cannot miss class more than twice.

The lectures will be recorded but only made available to those who miss lectures with excused absence.

For ETH students: Your grade will consist of two parts:
1) You will take weekly computer-based quizzes during class time. Thus, it is important that you attend the lectures to be able to finish the quizzes and pass this course.
2) You compose short responses to take-home questions on case studies we assign and upload them ahead of class (Pass/Fail).

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH students also have to complete an additional group project. UZH and UNISG students should check out the description of the class at their respective home institutions.

Handouts, prerecorded videos, slides, case studies, and other materials available on a dedicated webpage: contractdesign.org. Access to this webpage is free of charge for ETH students as ETH purchased a license for ETH students.

UZH and UNISG students should check out the description of the class at their respective home institutions.

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH students also have to complete an additional group project. UZH and UNISG students should check out the description of the class at their respective home institutions.

If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gercke (lucas.gercke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Negotiation: assessed
- Creative Thinking: assessed

Personal Competencies

851-0760-00L Building a Robot Judge: Data Science for Decision-Making

Abstract

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work. Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

851-0732-06L Law & Tech

Abstract

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective

The course is designed for a wide range of ETH students as well as for law students who are keen to deepen their understanding of cutting-edge technology. It offers an overview of key legal areas important for technology regulation, complemented by guest lectures on emerging technological trends.

In previous years, the course has featured esteemed speakers from various sectors, including industry leaders like Google, NGOs such as Digital Society Switzerland and The European Consumer Organization, regulatory bodies like the Swiss Competition Commission, and noted academics.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.
Adaptability and Flexibility fostered Communication fostered

The planned course outline is below.

- Overview of Law and Technology
- Fundamental Rights
- AI & Discrimination
- Landmark Big Tech Cases
- Regulation of Digital Platforms & Content Moderation
- Online Consumer Protection
- Law and Tech Scholarship Series

A number of recent regulations will be discussed, including the EU's AI Act, the Digital Services Act (DSA), and the Digital Markets Act (DMA), as well as emerging internet phenomena, like ChatGPT.

Prerequisites / notice
You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Law & Tech (851-0732-06L, HS 2024)" and enroll.

Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tr>
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<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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851-0391-00L Focus on the Human: Human-Centered Security and Privacy Lab

The course is particularly suitable for all students who have already completed the course “Human-centered IT Security and Privacy” as some of the concepts introduced will practically be applied in this course. However, the relevant literature and necessary material will be provided to all students and basic concepts will be briefly summarized so that all interested students can participate.

Abstract
After an introduction on usable security as the intersection of computer science and psychology, students will form teams and work on exemplary security- or privacy-related research questions. The teams will develop and evaluate a concept for a human-centered solution. Through input sessions and milestone presentations the human perspective will be incorporated and reflected upon.

Objective
At the beginning of the course, the students will receive an introduction to usable IT security and privacy and relevant concepts. Afterwards, a selection of current research questions from that area will be presented. The students form teams and select one of the proposed research questions. This question will accompany the students throughout the semester. They will design and evaluate a concept for a human-centered design solution to that question. To be able to do so, they will receive input on human-centered design and evaluation tools. Their progress and the inclusion of the human perspective will be subject to feedback in milestone presentations.

The students’ human-centered solution can take the form of a concept (e.g., a concept for a product or app), interface (e.g., a visual or tangible interface), or prototype (e.g., sketches, a click-dummy or a built prototype). The solution will then be subject to evaluations. The solutions will be user-tested by members of other teams that thereby take the perspective of a user themselves. In addition, the solutions will be analyzed from different stakeholders’ perspectives, such as developers or website owners.

Finally, the students will reflect on potential changes that result from the evaluations and their consequences.

Literature


Prerequisites / notice
This course is especially recommended after the related lecture "851-0390-00 G Human-Centered IT Security and Privacy". However, previous participation in the lecture is not a requirement and not necessary for succeeding in the course.

Competencies

| Subject-specific Competencies | Concepts and Theories | fostered |
| Method-specific Competencies  | Analytical Competencies | assessed |
|                               | Decision-making       | assessed |
|                               | Media and Digital Technologies | fostered |
| Social Competencies           | Cooperation and Teamwork | assessed |
|                              | Customer Orientation   | fostered |
|                              | Sensitivity to Diversity | fostered |
| Personal Competencies         | Adaptability and Flexibility | fostered |
|                              | Creative Thinking     | fostered |
|                              | Critical Thinking     | fostered |
|                              | Integrity and Work Ethics | fostered |
|                              | Self-awareness and Self-reflection | assessed |
|                              | Self-direction and Self-management | fostered |

851-0763-00L Supervised Research (Law, Economics, and Data Science)

Does not take place this semester.
This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from econometrics and machine learning to questions in law, data science, and social science.

Students must have some data science and/or statistics experience. Some programming experience in Python, Stata, or R is required.

Apply tools from data science and social science to a new project, potentially in a group, to develop a paper or app.

Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

**Objective**

**851-0392-00L** Privacy Quantification and Usable Protection

| W | 3 credits | 2S | N. Zufferey, V. Zimmermann |

**Abstract**

Students will gain an overview of the main privacy metrics that are used to evaluate privacy risks related to the use of a given technology. They will also be introduced to the concepts of privacy/utility balance and usable security. Practical exercises and reading of recently published scientific articles will be used to present practical cases of the theoretical tools presented in class.

**Objective**

This course aims to provide the students with a global knowledge of the concepts related to privacy, and the methodology and tools to identify, analyze, and address threats while taking the user into account in the process. They will adopt a "privacy mindset," thus enabling them to automatically take privacy into account, in a usable way, when designing or analyzing a system.

**Content**

First, the course will introduce the different definitions and approaches of privacy (e.g., privacy by control, privacy by design) as well as the ethical concerns and considerations related to information security and privacy research (e.g., responsible disclosure, full disclosure).

Second, the students will be introduced to the different methods, properties, and metrics to assess and/or guarantee a certain level of privacy. They will be introduced to the properties and metrics related to anonymization (e.g., k-anonymity, l-diversity), data aggregation (e.g., randomized responses, ε-differential privacy), as well as other privacy assessment methodologies (e.g., inferential privacy).

Third, the course will address usability issues and the role of individuals (i.e., users) in privacy management (i.e., usable security and privacy) and the design of privacy-enhancing technologies. In this context, we will analyze the main concepts seen during the course and discuss their advantages and disadvantages in terms of usability, as well as their implementation for mass-market and large-scale technologies.

Across all three parts of the course, practical exercises, as well as recent research articles reading, and presentations will be used as a complement to support the concepts seen in class, as well as to provide concrete examples of methodologies related to the assessment of privacy in general.

**Literature**


**Competencies**

**Subject-specific Competencies**

- Concepts and Theories
  - Assessed
- Techniques and Technologies
  - Assessed

**Method-specific Competencies**

- Analytical Competencies
  - Fostered
- Social Competencies
  - Fostered
- Personal Competencies
  - Fostered

**D-MAVT**

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<thead>
<tr>
<th>Number</th>
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<td>Contract Design I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Stremitzer, A. Tacconelli</td>
</tr>
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</table>

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L: Fall 2023)” and enroll. The password is “ContractDesign01”.

It is NOT a legal drafting class focused on contractual language.

Number of participants limited to 160.

Max 80 ETHZ and 80 UZH Students

Abstract

Contract Design I is taught by Professor Stremitzer and aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place and then engineer contracts that achieve the desired outcome.
Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Contract Design will provide you with analytical tools to design contracts that help you be better lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie financing, production & distribution, construction & development, M&A deals, venture capital financing, to executive compensation and many other types of transactions.

The course follows a flipped-classroom model: You will watch learning videos specifically produced for this course ahead of class. We will use class time to discuss real-world case studies. The videos will be made available before the lecture each week and need to be watched ahead of coming to class. Computer-graded quizzes at the beginning of each class will test students’ understanding of the concepts introduced in the videos.

As the emphasis of this class is on class discussion, attendance is mandatory. Absent important reasons, you cannot miss class more than twice.

The lectures will be recorded but only made available to those who miss lectures with excused absence.

For ETH students: Your grade will consist of two parts:
1) You will take weekly computer-based quizzes during class time. Thus, it is important that you attend the lectures to be able to finish the quizzes and pass this course.
2) You compose short responses to take-home questions on case studies we assign and upload them ahead of class (Pass/Fail).

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH students also have to complete an additional project. UZH and UNISG students should check out the description of the class at their respective home institutions.

Handouts, prerecorded videos, slides, case studies, and other materials available on a dedicated webpage: contractdesign.org. Access to this webpage is free of charge for ETH students as ETH purchased a license for ETH students.

If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Sergei von Steiger (sergei.vonsteiger@gess.ethz.ch).

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

The lecture addresses students in the fields of engineering, science and other related technical fields.

Note that UZH and UNISG students enrolling in this course need to earn more ECTS for completing this course than ETH students (due to curricula reasons). This is why UZH and UNISG students must complete a written assignment in addition to the weekly quizzes and take-home questions. UZH and UNISG students should check out the description of the class at their respective home institutions.

The lectures will be recorded but only made available to those who miss lectures with excused absence.

Prerequisites / notice
- Attendance is mandatory. You are only allowed to miss two lectures unless there are special circumstances.
- Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT.
- If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Sergei von Steiger (sergei.vonsteiger@gess.ethz.ch).

### Competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving

**Method-specific Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Negotiation

**Social Competencies**
- Creative Thinking

**Personal Competencies**
- Creative Thinking

### Abstract

The lecture addresses students in the fields of engineering, science and other related technical fields.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

The lecture addresses students in the fields of engineering, science and other related technical fields.

### Objective

The lecture addresses students in the fields of engineering, science and other related technical fields.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

The lecture addresses students in the fields of engineering, science and other related technical fields.

### Prerequisites / notice

The lecture addresses students in the fields of engineering, science and other related technical fields.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.
Subject-specific Competencies
Environmental Ethics (University of Zurich)

2V
fostered
assessed

Basic concepts of law, sources of law.
The thematic foci include: Industrialization, urban growth, democratisation and mass politics, shifting gender roles and ideals, and the
Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Analytical Competencies
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law. They are able

Sensitivity to Diversity
3 credits

Concepts and Theories
Subject-specific Competencies
At the end of this lecture course, students can: (a) highlight the most important changes in the "long nineteenth century" in Britain (b) explain their long-term effects (also for other European countries) and (c) relate these changes to global developments today.

Introduction to Law
W 2 credits 2V O. Streiff Gnöpff

Abstract
This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private
law and the law of the EU are covered. The focus is on legal problems related to space. Active participation is expected in short interactive
sequences.

Objective
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law. They are able
to apply the fundamentals in more advanced law classes and to recognize the relevance of law in their own field.

Content
Basic concepts of law, sources of law.
Private law; Contract law (particularly contract for work and services), tort law, property law.
Public law: Human rights, administrative law, procurement law, procedural law.
Insights into the law of the EU.

Lecture notes
Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Language
Further documents will be available online (https://moodle-app2.let.ethz.ch/course/view.php?id=22904).

Competencies
Subject-specific Competencies
Method-specific Competencies
Social Competencies

World Politics Since 1945: The History of International Relations (Without Exercises)
W 3 credits 2V A. Wenger

Abstract
This lecture series provides students with an overview of the development of international relations since the end of World War II. The first
part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period
after the transformation of 1989/91; the focus here is on current issues in international security policy.

Objective
By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations
since the end of the Second World War.

Content
of "Diploma Supplement"
Prerequisites / notice
The lecture is being supported by a website on Moodle. If you have any questions, please contact Fabio Schmocker (fabio.schmocker@sipo.gess.ethz.ch)

Competencies
Subject-specific Competencies
Method-specific Competencies
Social Competencies

History Part One: Europe (The Cradle of Modernity, Britain, 1789-1914)
W 3 credits 2V H. Fischer-Tiné

Abstract
A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture
series looks at several key aspects of these modernization processes and ask about their continuing relevance for our times. The regional
focus lies on Britain, where these processes took place for the first time.

Objective
At the end of this lecture course, students can: (a) highlight the most important changes in the "long nineteenth century" in Britain (b) explain their long-term effects (also for other European countries) and (c) relate these changes to global developments today.

Content
The thematic foci include: Industrialization, urban growth, democratisation and mass politics, shifting gender roles and ideals, and the
emergence of consumerism and leisure culture.

Lecture notes
Power Point Slides and references will be made available in digital form during the course of the semester.

Literature
Mandatory and further reading will be listed on the course plan that is made available as from the first session.

Prerequisites / notice
This lecture series does not build upon specific previous knowledge by the students.

Competencies
Subject-specific Competencies
Method-specific Competencies
Social Competencies

Environmental Ethics (University of Zurich)
W 3 credits 2V

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: 07SMEEE266

Please register at:
The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation. Security and Privacy Lab

The course is particularly suitable for all students who have already completed the course “Human-centered IT Security and Privacy” as some of the concepts introduced will practically be applied in this course. However, the relevant literature and necessary material will be provided to all students and basic concepts will be briefly summarized so that all interested students can participate.
Abstract
After an introduction on usable security as the intersection of computer science and psychology, students will form teams and work on exemplary security- or privacy-related research questions. The teams will develop and evaluate a concept for a human-centered solution. Through input sessions and milestone presentations the human perspective will be incorporated and reflected upon.

Objective
The course makes students experience an exemplary human-centered design process. They will learn about and practically apply human-centered design and evaluation methods that will allow them to view their solution from the human perspective, e.g., the user, developer or website owner perspective. By taking part in the evaluation of other teams, they will also take the user perspective themselves.

Content
At the beginning of the course, the students will receive an introduction to usable IT security and privacy and relevant concepts. Afterwards, a selection of current research questions from that area will be presented. The students will form teams and select one of the proposed research questions. This question will accompany the students throughout the semester. They will design and evaluate a concept for a human-centered solution to that question. To be able to do so, they will receive input on human-centered design and evaluation tools. Their progress and the inclusion of the human perspective will be subject to feedback in milestone presentations. The students’ human-centered solution can take the form of a concept (e.g., a concept for a product or app), interface (e.g., a visual or tangible interface), or prototype (e.g., sketches, a click-dummy or a built prototype). The solution will then be subject to evaluations. The solutions will be user-tested by members of other teams that thereby take the perspective of a user themselves. In addition, the solutions will be analyzed from different stakeholders’ perspectives, such as developers or website owners. Finally, the students will reflect on potential changes that result from the evaluations and their consequences.

 Literature

Literature Recommendations:


Prerequisites / notice

This course especially recommended after the related lecture "851-0390-00 G Human-Centered IT Security and Privacy". However, previous participation in the lecture is not a requirement and not necessary for succeeding in the course.

851-0763-00L
Supervised Research (Law, Economics, and Data Science)

Does not take place this semester.

Abstract
This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from ecometrics and machine learning to questions in law, data science, and social science.

Objective
Students must have some data science and/or statistics experience. Some programming experience in Python, Stata, or R is required.

Prerequisites / notice

Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

851-0453-00L
Artificial Intelligence and Human Values

Abstract
This course introduces students to the ethical, political and legal debates and transformations in relation to Artificial Intelligence and provides students with concepts and methods from the constructivist and interpretive social sciences to work towards responsible and democratic human-technology futures.

Objective
Apply tools from data science and social science to a new project, potentially in a group, to develop a paper or app.

Prerequisites / notice

Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

851-0392-00L
Privacy Quantification and Usable Protection Mechanisms

Abstract
Students will gain an overview of the main privacy metrics that are used to evaluate privacy risks related to the use of a given technology. They will also be introduced to the concepts of privacy/utility balance and usable security. Practical exercises and reading of recently published scientific articles will be used to present practical cases of the theoretical tools presented in class.
Objective

This course aims to provide the students with a global knowledge of the concepts related to privacy, and the methodology and tools to identify, analyze, and address threats while taking the user into account in the process. They will adopt a “privacy mindset”, thus enabling them to automatically take privacy into account, in a usable way, when designing or analyzing a system.

Content

First, the course will introduce the different definitions and approaches of privacy (e.g., privacy by control, privacy by design) as well as the ethical concerns and considerations related to information security and privacy research (e.g., responsible disclosure, full disclosure).

Second, the students will be introduced to the different methods, properties, and metrics to assess and/or guarantee a certain level of privacy. They will be introduced to the properties and metrics related to anonymization (e.g., k-anonymity, l-diversity), data aggregation (e.g., randomized responses, ε-differential privacy), as well as other privacy assessment methodologies (e.g., inferential privacy).

Third, the course will address usability issues and the role of individuals (i.e., users) in privacy management (i.e., usable security and privacy) and the design of privacy-enhancing technologies. In this context, we will analyze the main concepts seen during the course and discuss their advantages and disadvantages in terms of usability, as well as their implementation for mass-market and large-scale technologies.

Across all three parts of the course, practical exercises, as well as recent research articles reading, and presentations will be used as a complement to support the concepts seen in class, as well as to provide concrete examples of methodologies related to the assessment of privacy in general.

Literature


Competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Communication

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Method-specific Competencies

Fostered

Fostered

Fostered

Fostered

Fostered

Fostered

Attributes

Techniques and Technologies

Analytical Competencies

Communication

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Prerequisites: Basic programming skills, elementary probability and statistics.

This course introduces mathematical and computational models to study techno-socioeconomic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and to communicate their results through a project report and a short oral presentation.

See your own field of study in a wider context (“Science in Perspective”), e.g. see the psychological, social, economic, environmental, historical, ethical or philosophical connections and implications. Learn to think critically and out of the box. Question what you believe you know for sure. Get to know surprising, counterintuitive properties of complex (non-linearly interacting, networked, multi-component) systems. Learn about collaboration.
By the end of the course, the students should be able to better understand the literature on complex social systems, develop their own models for studying specific phenomena and report results according to the standards of the relevant scientific literature by presenting their results both numerically and graphically.

At the end of the course, the students will deliver a report, computer code and a short oral presentation. To collect credit points, students will have to actively contribute and give a circa 30 minutes presentation in the course on a subject agreed with the lecturers, after which the presentation will be discussed. The presentation will be graded.

Students are expected to implement themselves models of techno-socio-economic processes and systems, particularly agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature, its presentation, and documentation by a project report.

The lecture slides will be presented on the course Moodle after each lecture.

Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Supervised Research (Law, Economics, and Data Science)

This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from econometrics and machine learning to questions in law, data science, and social science.

Students must have some data science and/or statistics experience. Some programming experience in Python, Stata, or R is required.

This course will review several case studies from the ancient, medieval and modern history of mathematics. The case studies will be analyzed from various philosophical perspectives, while situating them in their historical and cultural contexts.
Objective
The course aims at:
1. To introduce students to the history of mathematics
2. To make sense of mathematical practices that appear unreasonable from a contemporary point of view
3. To develop critical reflection concerning the nature of mathematical objects
4. To introduce various theoretical approaches to the philosophy and history of mathematics
5. To open the students' horizons to the plurality of mathematical cultures and practices

Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Sensitivity to Diversity
- Personal Competencies: Critical Thinking

Concepts and Theories
- Analytical Competencies
- Sensitivity to Diversity
- Critical Thinking

Analytical Competencies
- Problem-solving
- Communication
- Critical Thinking

Social Competencies
- Communication

Personal Competencies
- Critical Thinking

Abstract
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined.

Objective
The objectives in this course are to (1) gain an overview of important questions pertaining to international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions in this policy area and how to address them in a conceptually and methodologically meaningful and insightful way; (3) gain an overview of important global and regional environmental problems and how they or could be solved.

Content
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
Reading materials and slides will be available via Moodle.

Prerequisites / notice
Access / Prerequisites
The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

Credits and Exam
After passing a written test at the end of the course (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test). Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory. Students who obtain a grade of < 4.0 for the test will have a second chance (see table below). Students who did not participate in the test on 19 December 2023 will not have access to the repeat test unless they submit compelling and documented (e.g. medical, other exam in parallel at ETH) reasons for why they were unable to participate in the first test. It covers all contents of the lectures and the reading assignments. Visiting students (e.g., from the University of Zurich or other universities) are subject to the same conditions. Registration for the course in the mysteries system of ETH is compulsory. No separate registration for the exam is required, registration for the course as such covers everything. The exam will take place on campus, either in the F3 lecture hall or in a computer room. That is, you must be present in person at ETH Zurich on the exam date/time.

Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Sensitivity to Diversity
- Personal Competencies: Critical Thinking

Abstract
System of swiss planning law, Constitutional and statutory provisions, Space planning and fundamental rights, Instruments, Application, legal protection, enforcement, Practical training.

Objective
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

Content

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

Abstract
Particularly suitable for students of D-ARCH, D-BAUG, D-USYS.

Objective
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

Content

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

Abstract
Particularly suitable for students of D-ITET, D-USYS.

Objective
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined.

Content
This course deals with how and why international problem-solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policy-making are examined, for example international efforts to reduce air pollution, manage international water resources, mitigate and adapt to global warming, protect the stratospheric ozone layer, address biodiversity challenges, deal with plastic waste, and prevent pollution of the oceans.

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
Reading materials and slides will be available via Moodle.

Prerequisites / notice
Access / Prerequisites
The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences or environmental policy. This course will take place on campus (ETH Main Building, HG F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course a few days after the respective lecture for students who are unable to attend in person. All electronic correspondence will take place via the ETH mystudies system and Moodle, so please make sure you are properly registered there with a functioning email address/account.

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Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Sensitivity to Diversity
- Personal Competencies: Critical Thinking

Abstract
Particularly suitable for students of D-ARCH, D-BAUG, D-USYS.

Objective
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

Content

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking
Environmental Ethics (University of Zurich)  

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 07SMEEE266

Please register at:
https://www.uzh.ch/cmsssl/de/studies/application/chmobilit yin.html

after you received your logon information you can enrol to courses at:
https://studentservices.uzh.ch/uzh/application/#/Logon

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Environmental Policy of Switzerland

This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are addressed from a political science perspective both theoretically as well as by means of current Swiss environmental policy examples.

Objective
Beyond acquiring basic knowledge about public policy analysis, this course teaches students how to analytically address current and concrete questions of environmental policy. Through exercises the students learn about political science concepts and frameworks as well as real-life political decision-making processes. The well-grounded examination of complex political conflict situations is an important precondition for the entry into the (environmental policy) workforce or a future research career.

Content
The processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

Competencies

Method-specific Competencies
Analytical Competencies assessed

Social Competencies
Sensitivity to Diversity assessed

Personal Competencies
Critical Thinking assessed
Self-direction and Self-management assessed

Real Estate Property Law

Particularly suitable for students of D-ARCH, D-BAUG, D-USYS.

Abstract
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

Objective
The legal principles of real estate property law can be correctly interpreted and applied in daily life.

Content
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

Lecture notes
Abgegebene Unterlagen: Skript in digitaler Form

Literature
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
To this end, we will look at the most important techniques of mediation and put them into the context of today's legislation, participation and communication.

- Develop comprehension of legal and social responses to environmental conflicts
- Apply tools from data science and social science to a new project, potentially in a group, to develop a paper or app.

Mediation in Environmental Planning: Theory and Practice

There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Supervised Research (Law, Economics, and Data Science)

This is a supervised student project for 3 ECTS, supervised by the professorship of Elliott Ash (D-GESS). Students will adapt tools from econometrics and machine learning to questions in law, data science, and social science. Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

Objective
- Students must have some data science and/or statistics experience. Some programming experience in Python, Stata, or R is required.
- Apply tools from data science and social science to a new project, potentially in a group, to develop a paper or app.
- Some programming experience in Python, Stata, or R is required. Some experience with data science or statistics is required.

Mediation in Environmental Planning: Theory and Practice

- Train communicative skills (presentation, moderation, discussion design, negotiation), especially by participating at a mediation case study.
- Develop concepts for doing and evaluating mediation processes
- Recognize the most important participative techniques and their ranges
- Estimate the potential and limitations of cooperative environmental planning
- Develop conflict analyses, for instance, as part of individual and group analyses and a half-day mediation-simulation, develop technique concepts and train their own communicative and negotiation skills.

Case Studies

This course explores the relation between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Lecture notes
A reader will be handed out.

Language Courses of the UZH and ETH Zurich

A maximum of 3 credit points from language courses may be recognised in the category "Science in Context" throughout the entire bachelor's and master's degree program. Moreover, the following restrictions apply: In the case of the European languages English, French, Italian and Spanish, only advanced language courses from level B2 will be credited. German language courses are credited from level C2.
Only the courses listed below will be recognized as "Science in Perspective" courses.

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursgebuehren1.html
Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0816-07L</td>
<td>French B2-C1: Language and Literature</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>University lecturers</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich.</td>
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<td>Book the corresponding course directly at &quot;Language Center of UZH and ETH Zürich&quot;.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>This course offers participants the opportunity to read short stories in order to raise their awareness of linguistic aspects and cultural issues in the Francophone world, and to improve their oral skills, mainly through oral presentations.</td>
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<tr>
<td></td>
<td>Objective</td>
<td>The primary objective of this course is to develop participants' written comprehension and, more specifically, to refine their perception of the implicit meanings and cultural aspects present in the literary texts proposed for reading. The course further aims to raise participants' awareness of contemporary cultural issues in the Francophone world. Another goal is to improve participants' oral skills, specifically so they can deliver structured presentations and express personal, informed, and nuanced opinions.</td>
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<td>851-0816-04L</td>
<td>French B2: Brush Up Your Skills</td>
<td>W</td>
<td>2</td>
<td>2G</td>
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<td>No enrolment to this course at ETH Zurich.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>The course is organized around the communicative tasks that participants learn to perform. These relate to the university environment and are addressed both in terms of essential language skills at B2 level and of extra-linguistic skills (cultural knowledge, gestures, etc.) required to deal with these situations.</td>
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<td>Objective</td>
<td>The objective of this course is to familiarize participants with the performance of communicative tasks specific to the academic world and, in so doing, to consolidate their general production and comprehension skills (oral and written) at B2 level.</td>
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<tr>
<td>851-0816-15L</td>
<td>French B2: Debating and Presentation Skills</td>
<td>W</td>
<td>1</td>
<td>1G</td>
<td>University lecturers</td>
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<td>Does not take place this semester.</td>
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<td>No enrolment to this course at ETH Zurich. Book the corresponding course directly at &quot;Language Center of UZH and ETH Zürich&quot;.</td>
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<td>Course fees:</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>This course offers participants the opportunity to initiate and practice debating in French by developing and improving specific linguistic tools in order to allow them to speak fluently in controversial discussions.</td>
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<td></td>
<td>Objective</td>
<td>This course allows participants to develop their speaking skills through active contributions in debates. More specifically, it aims at participants' production of clear and reasoned statements to ensure better communication. An additional goal is to improve participants' listening comprehension skills.</td>
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<tr>
<td>851-0816-08L</td>
<td>French B2-C1: Debating and Presentation Skills</td>
<td>W</td>
<td>1</td>
<td>1G</td>
<td>University lecturers</td>
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<td></td>
<td>No enrolment to this course at ETH Zurich.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>Based on the main controversial issues of the moment, this course offers participants the opportunity to reflect on the rhetorical tools essential to the art of debate and to put these tools into practice in order to improve their ability to express themselves quickly, effectively, and fluently.</td>
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<td></td>
<td>Objective</td>
<td>This course allows participants to develop specific skills in oral expression, as well as comprehension, in the context of controversial discussion. After observing various practices and rhetorical tools in the art of debate in an initial phase, participants put the theory into practice in order to produce clearly structured argumentation and improve their ability to interact effectively rhetorically and quickly in a controversial debate.</td>
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<tr>
<td>851-0816-05L</td>
<td>French B2-C1: Textual Grammar</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>University lecturers</td>
</tr>
<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich.</td>
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<td></td>
<td>Registration dates:</td>
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</table>
This course offers participants the opportunity to recognize, practice, and improve some of the fundamental and relevant linguistic tools they need in order to write academic texts in French.

The main objective of this course is to improve participants' competence in written French through the mastery of grammatical rules and their practical application; this will ensure the correctness of participants' utterances at text level and help them with some difficult areas of the French language. The course focuses on a descriptive approach of linguistic tools to improve written academic French (reports, abstracts) and business writing in general (covering letters) through targeted exercises.

**Italian B2-C1: Outside the Classroom**

*Does not take place this semester.*

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursgebuehren1.html

Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

**Italian B2-C1: Language Structure**

*Does not take place this semester.*

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursgebuehren1.html

Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

**English Language and Literature (C1-C2)**

*No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".*

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursgebuehren1.html

Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

**Advanced English for Academic Purposes (C1-C2)**

*No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".*

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursgebuehren1.html

Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

This course is designed for Bachelor’s and Master’s students from all disciplines who wish to improve their English from C1 towards C2 level and train their language skills at mastery level. Selected academic English features are included to add value to the course to meet standard entrance requirements by leading universities and colleges worldwide.
The course aims to train and develop linguistic skills at mastery level, with a focus on formal and informal academic lexis, on listening and oral communication skills, and on increasing fluency, accuracy, and complexity of spoken language. Students will work on writing well-structured descriptive texts and argumentative essays, with the aim of fulfilling the language requirements for study at an English-speaking university or following university Master’s courses held in English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Language Level</th>
<th>Credits</th>
<th>University Lecturers</th>
</tr>
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<tbody>
<tr>
<td>851-0846-01L</td>
<td>Spanish B2: Starter</td>
<td>W</td>
<td>2 credits</td>
<td>University lecturers</td>
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<tr>
<td>851-0846-03L</td>
<td>Spanish B2: Grammar and Communication</td>
<td>W</td>
<td>2 credits</td>
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<tr>
<td>851-0849-00L</td>
<td>Brazilian Portuguese A1</td>
<td>W</td>
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<tr>
<td>851-0849-01L</td>
<td>Brazilian Portuguese A2</td>
<td>W</td>
<td>2 credits</td>
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<tr>
<td>851-0849-02L</td>
<td>Brazilian Portuguese B1</td>
<td>W</td>
<td>2 credits</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>
Participants are able to use Modern Greek adequately in selected areas. They have basic vocabulary skills, which they can use actively.

Modern Greek Language III A2.1
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Objective
Participants can deal with everyday situations; they can talk about their experiences, opinions, wishes, and plans in simple coherent sentences.

851-0885-09L Modern Greek Language I A1.1
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
This course is designed for participants with an A2 level in Portuguese. The course deals with everyday topics. Participants practice forms of communication as these occur in daily life. Lexical and linguistic structures are taught within these contexts. Intercultural and socio-cultural issues relating to Brazil are also taken into consideration.

Objective
Participants are able to use Portuguese adequately in selected areas. They can read and write Portuguese script well. They can filter out a general overview from the information presented on Portuguese websites. The focus is on speaking, reading comprehension, and writing Portuguese script. The focus is also on building basic vocabulary and on acquiring basic grammar.

851-0885-10L Modern Greek Language III A2.1
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
Modern Greek I leads to A1.1 level on the Common European Framework of Reference for Languages. It is the first part of a four-semester Modern Greek course. The goal of the course is for participants to acquire basic language skills in speaking, listening comprehension, and reading and writing Greek script. The focus is also on building basic vocabulary and on acquiring basic grammar.

Objective
Participants are able to use Modern Greek adequately in selected areas. They improve their listening comprehension skills and expand their vocabulary. They can read and write Greek script well. They can filter out a general overview from the information presented on Greek websites. The focus is on speaking, reading comprehension, and listening comprehension skills at A1.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. Content areas that are embedded in various communicative tasks include: Giving information about yourself, your job, your studies, your place of residence, and your personal preferences; and conducting simple, everyday conversations (including ordering food and drink, shopping, and inquiring about places).

851-0889-00L Swedish I A1.2
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
Swedish I leads to A1.2 level on the Common European Framework of Reference for Languages. The course is the first part of a two-semester Swedish course. The goal of the course is for participants to gain basic language skills in speaking, listening comprehension, reading, and writing.

Objective
Participants are able to use Swedish adequately in selected areas. They can talk about past experiences and future plans; participating in interviews; asking for permission; giving advice; making appointments; and acting out dialogues.

851-0889-02L Swedish II A2.1
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
Swedish II leads to A2.1 level on the Common European Framework of Reference for Languages. The course is the second part of a two-semester Swedish course. The goal of the course is for participants to extend their skills in speaking, listening comprehension, reading, and writing. Participants expand their skills in basic grammar, extend their vocabulary and improve their pronunciation.
Participants are able to use Swedish adequately in selected areas. The focus is on speaking, listening comprehension, and reading comprehension skills at A1.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. Content areas that are embedded in various communicative tasks include: Talking about your relatives and family; talking about past and future events; expressing your views on things you (don't) like; expressing your opinion; and requesting information (including about directions and the weather).

Course fees:

Registration dates:

Objective
Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A1.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. The course deals with the following content: Talking about the weather; naming the seasons and months; understanding activities offered to tourists; expressing agreement, disagreement, and indifference; making appointments; talking about holiday plans and arrangements; expressing prohibitions; making comparisons; talking about learning; indicating date and year; saying what you are interested in and what you are doing; giving biographical details; saying what you would like to do; making and obtaining recommendations; passing on information.

Course fees:

Registration dates:

Objective
Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A2.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. The course deals with the following content: Talking about the weather; naming the seasons and months; understanding activities offered to tourists; expressing agreement, disagreement, and indifference; making appointments; talking about holiday plans and arrangements; expressing prohibitions; making comparisons; talking about learning; indicating date and year; saying what you are interested in and what you are doing; giving biographical details; saying what you would like to do; making and obtaining recommendations; passing on information.

Course fees:

Registration dates:

Objective
Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A2.2+ level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. The course deals with the following content: Talking about the weather; naming the seasons and months; understanding activities offered to tourists; expressing agreement, disagreement, and indifference; making appointments; talking about holiday plans and arrangements; expressing prohibitions; making comparisons; talking about learning; indicating date and year; saying what you are interested in and what you are doing; giving biographical details; saying what you would like to do; making and obtaining recommendations; passing on information.
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<tr>
<th>Code</th>
<th>Title</th>
<th>Objective</th>
<th>Course fees</th>
<th>Registration dates</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>851-0863-00L</td>
<td>Arabic III A2.1</td>
<td>Participants are able to use the Arabic language adequately in selected areas and can conduct themselves in a culturally appropriate manner. To this end, the following content is dealt with: Talking about your life; daily routines; expressing wishes, commands, and eventualities; and talking about language and language learning (meta-language skills). Culturally, the focus is on useful phrases and appropriate conduct on important occasions such as holidays, weddings, births, and deaths. In terms of grammar, this course attaches particular importance to the systematization of the Arabic verbal system.</td>
<td><a href="https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursebuehren1.html">https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursebuehren1.html</a></td>
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<td>2 credits</td>
<td>2G</td>
<td>University lecturers</td>
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<tr>
<td>851-0877-00L</td>
<td>Chinese I A1.1</td>
<td>Participants are able to use the Chinese language appropriately in selected areas and can conduct themselves in a culturally appropriate manner. The focus is on oral language skills at A1.1 level of the Common European Framework of Reference for Languages. There is a special focus on university and student life. Participants are familiar with the basics of pronunciation, Chinese script, and the writing of Chinese characters by hand and digitally. Regarding writing, the focus is on passive skills. The following topics are integrated into various communicative situations: - Greetings, farewells, thanking people, and other polite expressions - Introducing oneself (name, age, work, where you come from, etc.) - Talking about how to get in touch with others (phone, social media, etc.) - Providing information and asking about locations - Discussing Chinese and other languages and dialects - Talking about families</td>
<td><a href="https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursebuehren1.html">https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursebuehren1.html</a></td>
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<td>3 credits</td>
<td>4G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0879-00L</td>
<td>Chinese III A2.1</td>
<td>Participants are able to use the Chinese language adequately in selected areas and can conduct themselves in a culturally appropriate manner. The focus is on oral language skills at A1.1 level of the Common European Framework of Reference for Languages. There is a special focus on university and student life. Participants are familiar with the basics of pronunciation, Chinese script, and the writing of Chinese characters by hand and digitally. Regarding writing, the focus is on passive skills. The following topics are integrated into various communicative situations: - Greetings, farewells, thanking people, and other polite expressions - Introducing oneself (name, age, work, where you come from, etc.) - Talking about how to get in touch with others (phone, social media, etc.) - Providing information and asking about locations - Discussing Chinese and other languages and dialects - Talking about families</td>
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<td><a href="https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html">https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html</a></td>
<td>3 credits</td>
<td>4G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0881-00L</td>
<td>Japanese I A1.1</td>
<td>Participants are able to use the Chinese language adequately in selected areas and can conduct themselves in a culturally appropriate manner. The focus is on oral language skills at A1.1 level of the Common European Framework of Reference for Languages. There is a special focus on university and student life. Participants are familiar with the basics of pronunciation, Chinese script, and the writing of Chinese characters by hand and digitally. Regarding writing, the focus is on passive skills. The following topics are integrated into various communicative situations: - Greetings, farewells, thanking people, and other polite expressions - Introducing oneself (name, age, work, where you come from, etc.) - Talking about how to get in touch with others (phone, social media, etc.) - Providing information and asking about locations - Discussing Chinese and other languages and dialects - Talking about families</td>
<td><a href="https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursebuehren1.html">https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursebuehren1.html</a></td>
<td><a href="https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html">https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html</a></td>
<td>3 credits</td>
<td>4G</td>
<td>University lecturers</td>
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</table>
Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Special importance is attached to an academic environment and student life. In addition, the two syllabic writing systems and the use of Japanese computer word processing are learnt. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and talking about yourself (personal and professional identity, studies, interests, daily life); asking for information; and requesting services.

851-0883-00L
**Objective**: Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Special importance is attached to an academic environment and student life. In addition, the two syllabic writing systems and the use of Japanese computer word processing are learnt. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and talking about yourself (personal and professional identity, studies, interests, daily life); asking for information; and requesting services.

**Abstract**: Japanese III leads to A1.2/A2.1 level on the Common European Framework of Reference for Languages. It is the third part of a five-semester Japanese course. The goal of the course is to give participants the opportunity to practice colloquial Japanese, read texts in Sino-Japanese mixed script, use and extend their basic vocabulary and sentence structures, and practice listening comprehension.

**Objective**: Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.2/A2.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Grammar skills are also reviewed and extended. Participants learn about 60 new KANJI, thus improving their reading skills. The following content from daily interactions is dealt with: Dealing with everyday interactions, talking about personal problems, giving advice, expressing wishes, and making assumptions.

851-0882-02L
**Objective**: Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.2/A2.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Grammar skills are also reviewed and extended. Participants learn about 60 new KANJI, thus improving their reading skills. The following content from daily interactions is dealt with: Dealing with everyday interactions, talking about personal problems, giving advice, expressing wishes, and making assumptions.

851-0856-06L
**Objective**: Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Special importance is attached to an academic environment and student life. In addition, the two syllabic writing systems and the use of Japanese computer word processing are learnt. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and talking about yourself (personal and professional identity, studies, interests, daily life); asking for information; and requesting services.

851-0827-01L
**Objective**: Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Special importance is attached to an academic environment and student life. In addition, the two syllabic writing systems and the use of Japanese computer word processing are learnt. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and talking about yourself (personal and professional identity, studies, interests, daily life); asking for information; and requesting services.

**Abstract**: This course offers participants the opportunity to read, and reflect in class on, challenging texts on societal issues that regularly appear on the French-language news agenda, in order to expand their cultural knowledge, and specifically, to improve their lexical skills in writing and speaking, as well as express complex personal opinions when speaking.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Module</th>
<th>Delivery Format</th>
<th>Lecturer Type</th>
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</thead>
<tbody>
<tr>
<td>851-0849-03L</td>
<td>Brazilian Portuguese A2-B2: Urban Popular Music</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0846-02L</td>
<td>Spanish B2-C1: Language and Cinema</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0856-04L</td>
<td>Spanish B2-C1: Grammar and Communication</td>
<td>W</td>
<td>2</td>
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<td>University lecturers</td>
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<tr>
<td>851-0816-13L</td>
<td>French B2.2-C2: Practising French in Context</td>
<td>W</td>
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<td>University lecturers</td>
</tr>
<tr>
<td>851-0820-01L</td>
<td>French B2-C1: Language and Cinema</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>
This course offers participants a choice of films that reflect recent issues in order to raise their awareness of the ongoing concerns of contemporary French cinema, and also to enable them to improve their speaking skills, mainly through oral presentations.

Objective
The primary objective of this course is to develop participants' listening comprehension skills and more specifically, to improve their understanding of implicit and cultural meanings of the films on the program. It further aims to raise participants' awareness of the history, aesthetics, and contemporary issues of French cinema. The second objective of the course is to improve participants' speaking skills, especially by giving them the opportunity to produce structured presentations and to express their personal, informed, and nuanced opinions.

851-0834-17L Spanish B2: Oral Interaction
Objective
Participants practice a range of oral interactions, such as casual and formal conversation, interviews, debates, negotiations, and presentations. They discuss current issues and their fields of study and/or work.

Objective
The course aims to expose participants to a range of conversational situations, providing them with tools that help them to improve their ability to perform various tasks linguistically and socially.

851-0826-04L Italian B2-C1: Language and Literature
Objective
Participants analyze and study the linguistic structures of these text genres and learn specialist vocabulary from their field of study.

Abstract
The course approaches the Italian language through short stories, relevant both for their linguistic structures and content, which is related to historical and sociological realities typical for Italy. Participants deepen their lexical and syntactic competence by means of oral and written presentations, class discussions, reflections on the structures of the stories, and targeted exercises.

Objective
The course offers participants the opportunity to:
- Understand through short narrative texts some cultural and social realities typical of Italy
- Learn how to express themselves clearly and in a differentiated way
- Be able to grasp nuances of meaning expressed through certain lexical and syntactical choices more effectively
- Better understand complex literary texts
- Understand through short narrative texts some cultural and social realities typical of Italy

851-0826-05L Italian B2: Italian for Academic Purposes
Objective
Participants analyze and study the linguistic structures of these text genres and learn specialist vocabulary from their field of study.

Abstract
In this course, participants examine and write/prepare various academic text genres, including scientific essays, abstracts, oral presentations, and handouts.

Objective
The course aims to deepen participants' mastery of academic language. By reading scientific texts and listening to university lectures, participants analyze and study the linguistic structures of these text genres and learn specialist vocabulary from their field of study.

851-0879-01L Chinese V 2.2+
Objective
Chinese V concludes the five-semester Chinese course. Chinese V goes beyond level A2.2 of the Common European Framework of Reference for Languages and includes some B1-level skills. The goal is to further develop oral skills, and listening and reading comprehension skills on selected topics. There is a special focus on university and student life.

Abstract
Chinese V concludes the five-semester Chinese course. Chinese V goes beyond level A2.2 of the Common European Framework of Reference for Languages and includes some B1-level skills. The goal is to further develop oral skills, and listening and reading comprehension skills on selected topics. There is a special focus on university and student life.

Objective
Participants are able to talk about selected topics and understand simple, authentic texts, audio sequences, and videos related to these topics. The focus is on oral language skills. Listening and reading comprehension and (digital) writing skills are also practiced, with the additional support of digital tools.

The following topics are integrated into various communicative situations:
- Travel: Destinations of choice; organizing and describing a trip, etc.
- Education and training: Your career; your current academic or professional situation; comparing the Swiss and Chinese education systems.

851-0867-00L Arabic I-III (Fast Track) A1-A2.1
Objective
Participants practice a range of oral interactions, such as casual and formal conversation, interviews, debates, negotiations, and presentations. They discuss current issues and their fields of study and/or work.

Objective
The course aims to expose participants to a range of conversational situations, providing them with tools that help them to improve their ability to perform various tasks linguistically and socially.

Abstract
The course approaches the Italian language through short stories, relevant both for their linguistic structures and content, which is related to historical and sociological realities typical for Italy. Participants deepen their lexical and syntactic competence by means of oral and written presentations, class discussions, reflections on the structures of the stories, and targeted exercises.

Objective
The course offers participants the opportunity to:
- Understand through short narrative texts some cultural and social realities typical of Italy
- Learn how to express themselves clearly and in a differentiated way
- Be able to grasp nuances of meaning expressed through certain lexical and syntactical choices more effectively
- Better understand complex literary texts
- Understand through short narrative texts some cultural and social realities typical of Italy

4G
Abstract

Arabic I-III (fast track) is an intensive course that leads to A2.1 level on the Common European Framework of Reference for Languages. The target group are people who: understand or speak an Arabic dialect and wish to learn Standard Arabic; have learnt to read Arabic fluently during a religious education; or have already learnt some basic Arabic and wish to invest time in an intensive course.

Objective

Participants are able to use the Arabic language adequately in selected areas and can conduct themselves in a culturally appropriate manner. To this end, the following content is dealt with: Talking about your life; daily routines; expressing wishes, commands, and eventualities; talking about language and language learning (meta-language skills); writing messages and short texts. In terms of grammar, this course attaches particular importance to the basic principles of the grammar of Standard Arabic and its verbal system. Among the cultural and meta-language skills are the creation of awareness regarding the difference between the Arabic varieties and registers.

Prerequisites / notice

In all cases, knowledge of Arabic script is a prerequisite.

851-0826-07L Italian B2: Communicative Forms and Strategies

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursgebuehren1.html

Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

Abstract

Participants improve their skills in
• Expressing their opinions and formulating hypotheses in different sequences and tenses
• Reporting on news, information, and questions from others
• Grammar and vocabulary at B2 level

Texts on everyday topics provide the learning context. Participants gain practice through interacting with others and consolidate their skills through written exercises

Objective

At the end of the course, participants can:
• Express themselves in various ways using formulations and structures appropriate to the given oral, written, and communicative context
• Use current tools such as DeepL and Chat GPT to improve their learning

851-0881-05L Japanese I A1.1 (Part 2)

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursgebuehren1.html

Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

Abstract

This course is the second part of the two-semester course in which the entire content of Japanese I A1.1 is learned. The goal of the course is for participants to learn the basic vocabulary and sentence structures needed to communicate in everyday situations. This includes an extension of existing knowledge of Hiragana and Katakana syllabic writing and its use in word processing.
Objective
Participants will have adequate language in selected everyday situations. Special consideration is given to an academic environment and student life. The Japanese I (Part 1) and Japanese I (Part 2) courses aim to cover the entire content of Japanese I A1.1 in two semesters. They are designed so that busy participants who can only attend Japanese classes once a week can slowly but steadily acquire A1.1 proficiency over the course of two semesters. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. In addition, the two syllabic writing systems and the use of Japanese computer word processing are expanded. Content areas that are embedded in various communicative tasks include: talking about yourself (personal and professional identity, interests, daily routine, etc.), asking for information, and requesting services.

Prerequisites / notice
Special admission requirement: Attendance of the course Japanese I A1.1 (Part 1) or equivalent knowledge.

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<th>Course Title</th>
<th>Schedule</th>
<th>Credits</th>
<th>Type</th>
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<td>French B2: Points of View on Current Affairs</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>University lecturers</td>
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Course fees:

Registration dates:

Abstract
In this course, we deal with current affairs from the French-speaking world through various media, both written and audio-visual. Each topic is approached from a different perspective, with an emphasis on group discussion. At the end of the course, participants choose and present one current topic from the French-speaking world and lead a discussion on their topic.

Objective
The objectives of this course are to provide the tools (linguistic and cultural) necessary to understand and address francophone current affairs. Participants work on specific vocabulary related to current affairs and communicative competence (expressing opinions; expressing agreement or disagreement; arguing). By the end of the course, participants are able to give a presentation in French on a chosen topic and propose and lead a discussion. The emphasis of the course is on oral interaction skills and written and oral comprehension (newspaper articles, reports, documentaries).

Science in Perspective - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
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<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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Key for Hours

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<td>U</td>
<td>exercise</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
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<td>diploma thesis</td>
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<tr>
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<td>revision course / private study</td>
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ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.